Confidential

Belize

Sustainable Energy Strategy

Volume 1

Final Report

Ministry of Energy, Science, Technology, and Public Utilities

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Acronyms

AC	Air conditioning
BAU	Business as usual
BEL	Belize Electricity Limited
BNE	Belize Natural Energy
CapEx	Capital expenditure
CFE	Federal Electricity Commission; *Comisión Federal de Electricidad*
CO_2	Carbon dioxide
DFC	Development Finance Corporation
EE	Energy efficiency
FTP	Full Tariff Period
GWh	Gigawatt hour
HFO	Heavy fuel oil
HPS	High-pressure sodium
IDA	International Development Association
IDB	Inter-American Development Bank
kW	Kilowatt
kWh	Kilowatt hour
LPG	Liquefied petroleum gas
LRMC	Long-run Marginal Cost
MESTPU	Ministry of Energy, Science, Technology, and Public Utilities
MIGA	Multilateral Investment Guarantee Agency
MWh	Megawatt hour
NPV	Net present value
NSES	National Sustainable Energy Strategy
O&M	Operations and Maintenance
OPIC	Overseas Private Investment Corporation
PPA	Power Purchase Agreement
PUC	Public Utilities Commission
PV	Photovoltaic
RE	Renewable energy
RSM	2008 Rate Setting Methodology

SIEPAC	Central American Electrical Interconnection System; Spanish: *Sistema de Interconexión Eléctrica de los Países de América Central*
SOC	Standard Offer Contract
TBR	Tariff Basket Revenue

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Executive Summary

Belize has an unrealized sustainable energy potential worth BZ$524 million (BZ$503 million not considering electricity exports) in net present value (NPV) over the period 2014 to 2033.

A National Sustainable Energy Strategy Scenario

Renewables could represent 89 percent of electricity supply, electricity consumption could decrease by 24 percent, and stationary fuel consumption could decrease by 19 percent—combining to lower greenhouse gas emissions by 2.4 million tons over the period. The savings from EE and RE are achieved by making upfront investments in EE and RE technologies that reduce future energy expenditures, either by lowering the amount of energy consumed (EE) or reducing the cost of the electricity (RE).

Belize uses some EE measures already, but their penetration is far below the potential. To develop our projection of the potential for EE in Belize we:

- Use audit data from 26 homes, businesses, and government buildings to develop sector-level energy use projections
- Apply money-saving EE measures to the observed end uses of energy to determine the maximum energy savings by sector
- Assume a penetration rate of EE that is achieved over the forecast period.

Belize already generates renewable energy from domestic sources, but it could generate more by expanding the use of the RE technologies it already uses (biomass and hydro), as well as by using new sources including wind, solar PV, anaerobic digestion, landfill gas, and small hydro. To generate our projection of Belize's RE generation potential we:

- Assess the availability of renewable resources in Belize
- Select commercially proven technologies that exploit those resources that reliably generate at a cost below the relevant cost of power in Belize
- Build a system expansion scenario to match demand.

The combined potential for EE and RE is estimated by comparing the net cost of electricity and stationary fuels in a business-as-usual scenario (BAU) scenario, with the net cost of electricity and stationary fuels in a national sustainable energy strategy (NSES) scenario.

Barriers and Recommendations

The scale of unrealized benefits from EE and RE suggests that there are barriers that prevent the realization of viable EE and RE projects. We identify the barriers specific to EE projects, distributed scale RE, and utility scale RE; we also develop preliminary recommendations on how to overcome those barriers.

Table ES 1 summarizes barriers to, and recommendations for EE; and Table ES 2 summarizes barriers to, and recommendations for RE.

Table ES 1: Barriers to, and Recommendations for EE

Type	Barriers	Recommendations
Agency	Private sector: developers and landlords have no incentive to invest in EE and prefer lower-cost, less-efficient equipment; those buying or renting are stuck with using that equipment, and also may have no incentive to invest in EE	Introduce a Building Code mandating EE
	Public sector: procurement officials are not incentivized to invest in EE; Government ends up paying more than it should for energy	Contract private sector firms to retrofit public building under contracts that align their success with energy savings; make Government departments directly responsible for energy bills
	BEL's does not have a strong incentive to control the costs it passes on to consumers	Implement regulation with stronger efficiency incentives for BEL
Information	Energy consumers don't know about cost and performance of EE measures	Implement public awareness initiatives; adopt a labeling system for EE products in coordination with other countries in the region; or develop national energy performance standards; consider requiring buildings to have energy management systems
	Energy consumers mistrust EE technologies that are new	Provide information about EE technologies; require retailers who participate in a financing facility to provide warranties
	Service/equipment providers and financiers are unfamiliar with EE opportunities—and so unable to adequately serve the market	Provide training (workshops, on-the-job training, embedded experts for 'pilot periods')
	Consumers do not know good vs. poor service providers	Adopt a certification system for EE services
Regulatory	BEL's tariff structure, as it is, is not an incentive for it to support EE for its customers or itself, which could limit Belize's ability to achieve its full EE potential	Improve decoupling of BEL revenues from sales of energy only, and allow it to better recover costs and earn a return on helping its customers implement EE
Market	EE equipment may be hard to find (especially out of Belize City), and may be priced to high	Implement consumer finance scheme with bulk purchases to increase volumes and reduce costs
Financial	Upfront cost of EE measures is high for consumers; financing institutions may not provide lending on appropriate terms for EE; non-creditworthy customers cannot finance EE, leading to sub-optimal outcome from a social welfare perspective	Provide concessional lending and other financial mechanisms for EE as part of a 'Sustainable Energy Fund' or similar instrument
Skills	Service providers, financiers, and public entities do not have the skills to take advantage of EE	Provide specialized training on required skills

Table ES 2: Barriers to, and Recommendations for RE

Distributed Scale RE

Type	Barriers	Recommendations
Regulatory	Owners of distributed RE systems cannot sell their excess generation	Provide a well-structured Standard Offer Contract for distributed renewable generation
	The tariff structure would make distributed generation hurt BEL's financial viability	Disaggregate the tariff structure to charge separately for energy, backup and standby, and connection to the grid
Technical	Inspection of systems might put strain on BEL	Certify third party inspectors for distributed RE systems

Utility Scale RE

Types	Barrier	Recommendations
Information	Lack of investment grade resource assessments	Produce resource assessments
Regulatory	Ability to use a renewable resource: unclear situation for hydro sites in the Upper Macal River	Solve the issues related to BECOL's agreements and license
	Ability to access and develop a site: unclear framework for unprotected and protected areas—although Government policy set to address it	Continue according to what outlined in the NEP, developing specific permitting and planning for RE that balances environmental protection with economic benefit
	Ability to sell electricity commercially: (1) limited licensing regime, and (2) a few weaknesses in RE tendering	Develop a full licensing regime issued by PUC; include items required for licensing in the RFP package; provide a best practice standard PPA as part of the RFP package; clarify qualification and evaluation stages and criteria; define 'public resource'
Financial	Possible limited investor interest and higher costs for large RE in Belize	Provide clear rules and governance for investments
Technical / Skills	Limited familiarity with grid interconnection of intermittent RE; limited experience operating RE plants not currently in use in Belize	Upgrade the Grid Code, and provide training and learning opportunities

1 Introduction

The Inter-American Development Bank (IDB) contracted Castalia to advise the Ministry of Energy, Science, Technology, and Public Utilities (MESTPU) of Belize on how the country can realize its energy efficiency (EE) and renewable energy (RE) potential. Achieving this potential could lower energy costs for Belizeans, increase energy security, and reduce greenhouse gas emissions.

This Final Report presents our assessment of Belize's EE and RE potential, the barriers that prevent that potential from being realized, and recommended interventions to overcome the barriers. This Final Report has been revised to incorporate the feedback obtained at the Final Validation Exercise held in Belize City on 28 October 2014 (in addition to feedback obtained earlier throughout the assignment), and includes an updated version of the Sustainable Energy Action Plan (submitted as a separate document) revised based on comments by MESTPU. Other key entities and stakeholders who were part of the consultative process include:

- The Development Finance Corporation (DFC)
- Belize Electricity Limited (BEL)
- The Public Utilities Commission (PUC)
- The business community (hotels, power developers, credit unions).

The remainder of this report:

- Presents a scenario for a NSES (Section 2). The scenario shows what Belize's energy matrix could look like in 2033 as compared to today's
- Shows the potential for EE (Section 3)
- Shows the potential for RE (Section 4)
- Presents the barriers that prevent good EE and RE projects from being realized (Section 5)
- Explains our preliminary recommendations on how to overcome the barriers (Section 6).

Appendices, contained in Volume 2:

- Provide detailed analysis on the EE technologies (Appendix A) and RE technologies (Appendix B) included in our analysis
- Provide audit reports for all the facilities audited by WSP and Young's Engineering (Appendix C).

2 Scenario for a National Sustainable Energy Strategy

Belize has an unrealized sustainable energy potential worth BZ$524 million (BZ$503 million not considering electricity exports) in net present value (NPV) over the period reaching year 2033. Renewables could represent 89 percent of supply, electricity consumption could decrease by 24 percent, and stationary fuel consumption could decrease by 19 percent—combining to lower greenhouse gas emissions by 2.4 million tons over the period. This potential is estimated by comparing the net cost of electricity and stationary fuels in a business-as-usual scenario (BAU) scenario, with the net cost of electricity and stationary fuels in a national sustainable energy strategy (NSES) scenario.

Table 2.1 summarizes the results of a NSES scenario against BAU, and shows the NSES' costs and benefits.

Table 2.1: Results of a Sustainable Energy Scenario

	NSES	BAU	NSES vs. BAU
Electricity consumption (2033)	1,121GWh	1,472GWh	**-24%**
Stationary fuel consumption (2033)	6,027TJ	7,412TJ	**-19%**
Electricity from RE (2033)	999.5GWh /1,121GWh (89%)	628GWh/ 1,472GWh (43%)	**89% vs. 43%**
Cumulative greenhouse gas emissions (2013–2033)	6.9 M tCO_2e	9.3 M tCO_2e	**-2.4 M tCO_2e**
CapEx for EE, electricity +stationary fuel use (NPV, 2013–2033)[1]	BZ$217M	BZ$0	**-BZ$217 M**
All-in cost of electricity supply (NPV, 2013–2033)	BZ$1,727 M	BZ$2,186 M	**BZ$459 M**
Value of stationary Fuel Use (NPV, 2013–2033)*	BZ$1,919 M	BZ$2,180 M	**BZ$261 M**
Electricity exports (NPV, 2013–2033)	BZ$21 M	BZ$0	**BZ$21 M**
Net Present Value (Reduced cost of elec. supply + reduced cost of stat. fuel use – EE CapEx)			**BZ$503 M**
NPV (including value of electricity exports)			**BZ$524 M**

*Includes the value of crude oil, liquefied petroleum gas (LPG), diesel, heavy fuel oil (HFO), and biomass

Note: All net present value calculations are discounted at a 10 percent annual rate; assumes current Mexico/Belize exchange rates for cost of power purchased from Mexico, which is subject to change

[1] This indicates capital expenditure beyond historic levels. In the BAU case it is assumed to be zero—this does not mean that no investment takes place, but rather that it continues to take place in line with historical trends.

The remainder of this section presents:

- The opportunity for sustainable energy in Belize (Section 2.1)
- A comparison of the BAU and NSPS scenarios in terms of electricity savings, fuel savings, and greenhouse gas emissions (Section 2.2).

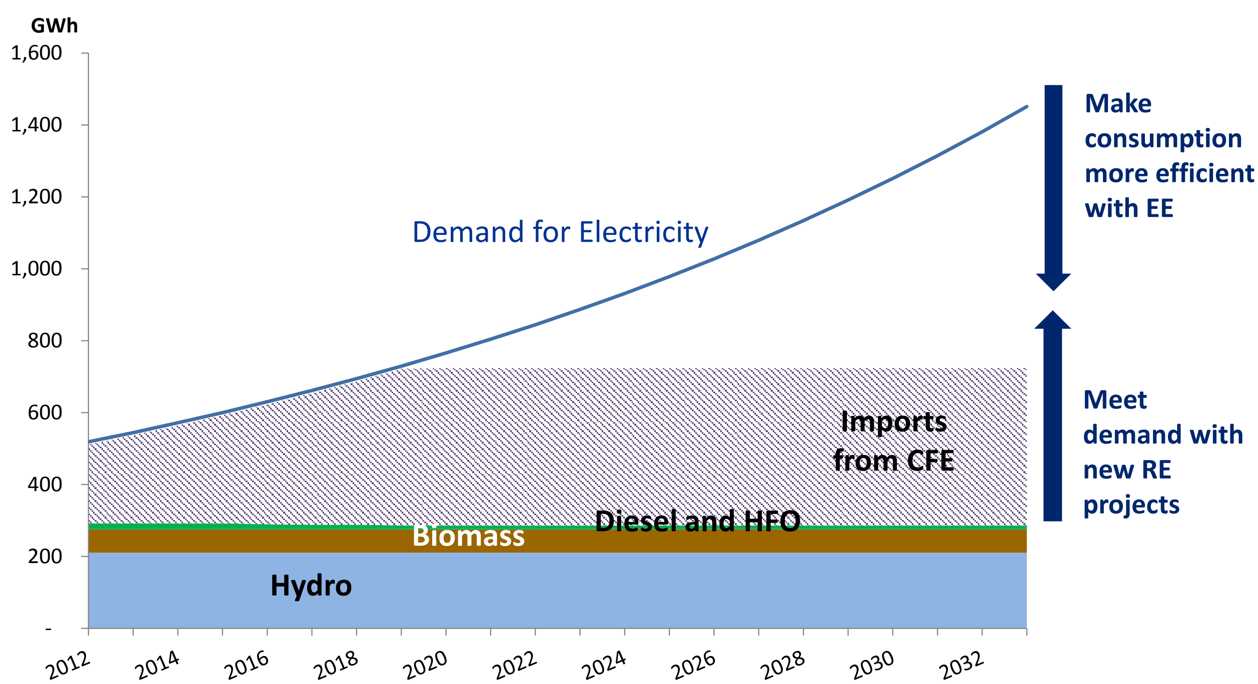
2.1 The Opportunity for Sustainable Energy in Belize

Demand for electricity and fuel for stationary use is growing in Belize. Belize would benefit from meeting this demand sustainably with a combination of demand reduction measures and increases in renewable supply. Belize has the opportunity to consume more efficiently and increase its use of energy from renewable sources both for electricity (Section 2.1.1) and for stationary use of fuels (Section 2.1.2).

2.1.1 Electricity

Belize faces growing demand for electricity; EE can reduce demand for it and RE can increase the supply. Figure 2.1 shows a projection of BAU electricity demand in Belize, as well as Belize's ability to meet that demand with existing assets (including the 50MW transmission line from Mexico).

Figure 2.1: The Opportunity for Sustainable Electricity



Source: BEL's 2009 expansion plan

Notes: The demand growth projection is based on BEL's 2009 expansion plan; annual generation profiles are based on 2012 performance

Demand for electricity in Figure 2.1 is based on projections from BEL's 2009 expansion plan. Figure 2.1 also assumes that existing power plants will be available to operate throughout the forecast period.

2.1.2 Stationary fuels

Belizean energy consumers use liquid fossil fuels for a number of non-transport applications. The residential and industrial sectors are the largest consumers in absolute terms. The key end uses and fuels by sector are:

- Industrial—industrial boilers in Belize burn locally produced crude to generate process heat for food processing and other applications; in many cases the boilers are designed to consume diesel, but the lower cost of crude makes it more attractive (though reducing oil production means that industrial users may switch back to diesel in the future)
- Residential—Liquefied petroleum gas (LPG) for cooking is the most common use of fossil fuel in this sector. To a lesser degree some homes use LPG for hot water heating
- Commercial—restaurants and hotels use LPG for cooking; hotels also use LPG for hot water heating.

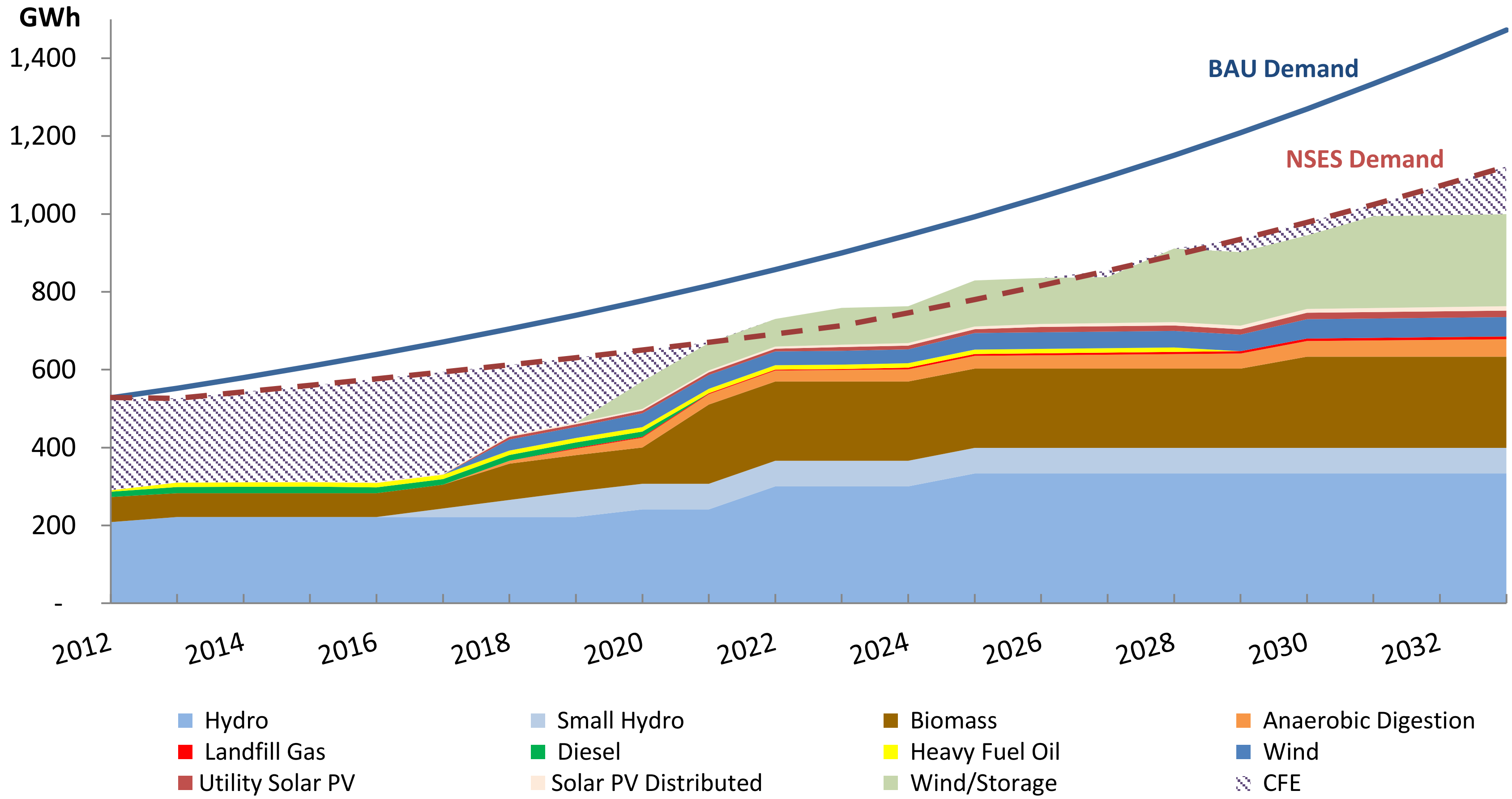
2.2 Comparing the NSES Scenario to BAU

The NSES scenario suggests that Belize can reduce its expenditure on energy while reducing its carbon emissions, using currently available technologies and techniques. Compared to the BAU scenario, the NSES scenario creates a net benefit of BZ$524 million over the forecast period, thanks to possible interventions in electricity (Section 2.2.1) and stationary fuel use (Section 2.2.2), and reduces carbon emissions by 2.4 million tCO_2e (Section 2.2.3). Both scenarios use 2012 as the base year of analysis because it is the most recent year for which full annual data are available. Increased capital costs for the NSES scenario are more than made up by savings (Section 2.2.4).

2.2.1 Electricity

The NSES scenario assumes an increased uptake of energy efficiency measures in Belize, as well as a significant expansion of Belize's electricity generation from renewable resources. Figure 2.2 shows what the NSES scenario means for demand and supply of electricity. The assumptions about the use of EE measures and RE used to develop Figure 2.2 are presented in Section 3 and Section 4, respectively.

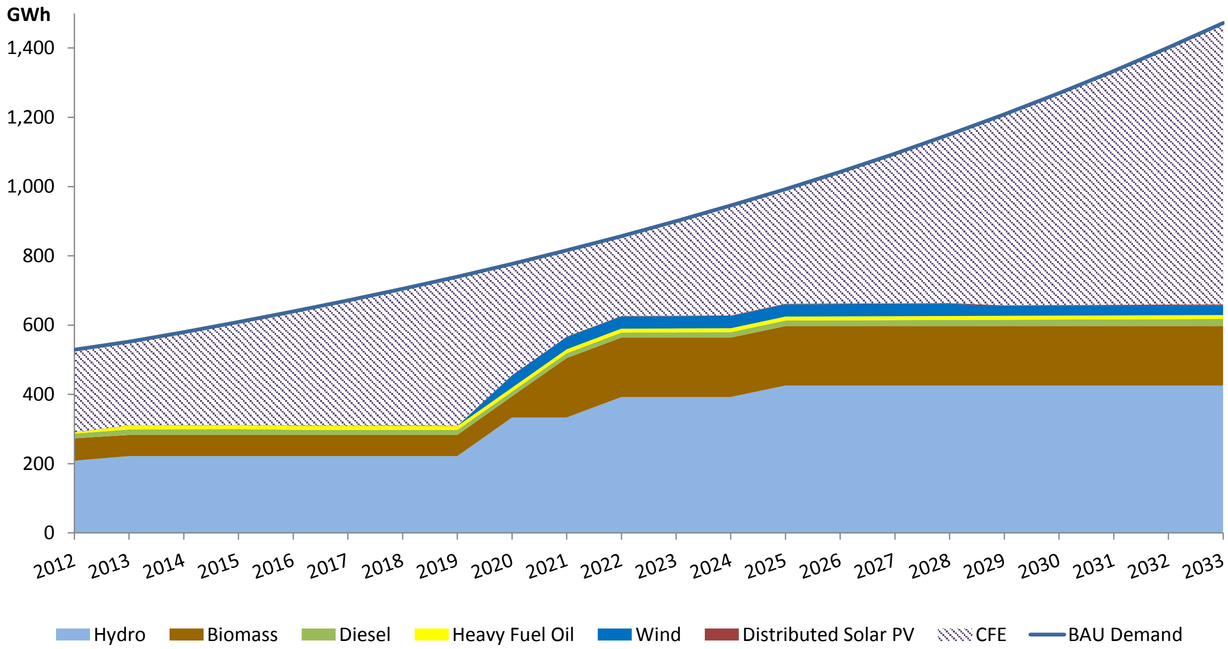
Figure 2.2: Belize's NSES Scenario—Electricity (2012–2033)



Note: BAU demand based on BEL demand projections from 2009 expansion plan; NSES demand based on our analysis of the potential for EE across the sectors; excess electricity is assumed to be sold to SIEPAC or to Mexico; power plants included are based on our assessment of available local resources, economic viability of the technologies, and reasonable development timeframes. Forecasts prepared in Microsoft Excel.

The costs and benefits of the NSES Scenario are compared to the BAU scenario presented in Figure 2.3 below.

Figure 2.3: Business as Usual Electricity Consumption and Generation (2012–2033)



Source: Castalia projections

The BAU demand forecast is based on BEL's projections from its 2009 expansion plan. The BAU scenario assumes the following:

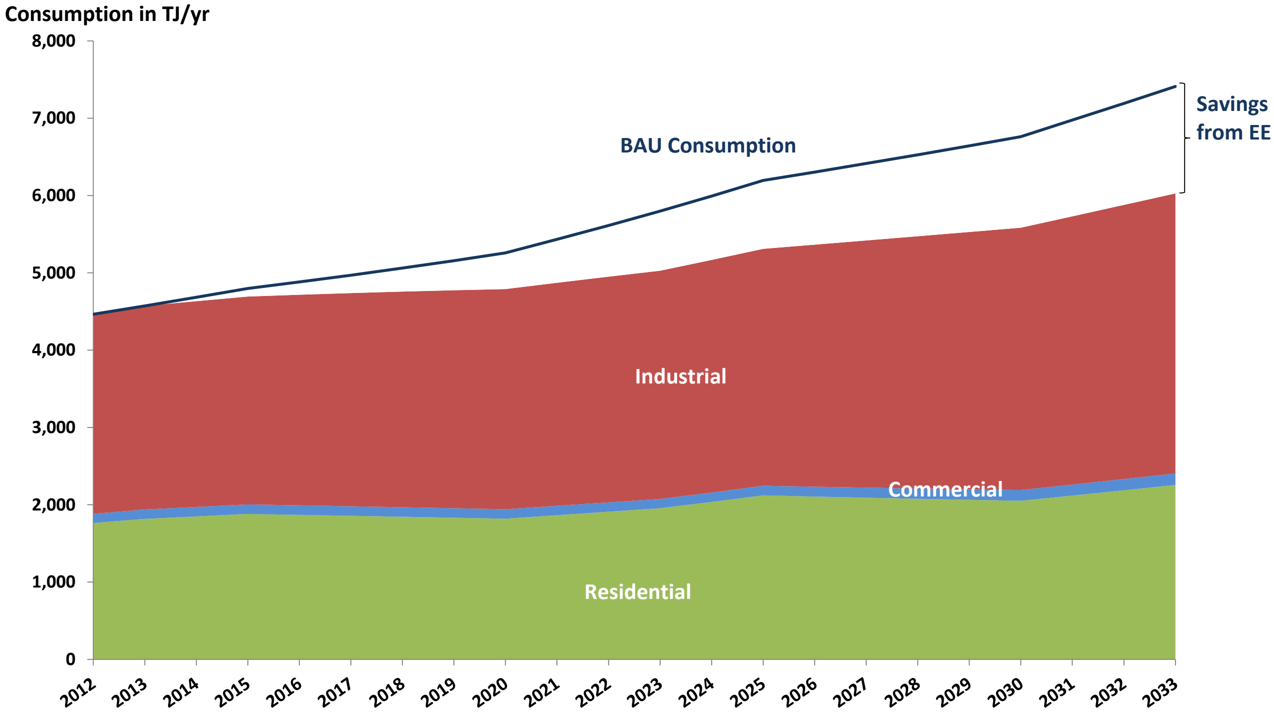
- The construction of a second 50MW link with Comisión Federal de Electricidad (CFE), as specified in the 2009 BEL expansion plan
- The increases in installed electricity generation capacity specified in the request for proposals issued by the Public Utilities Commission (PUC) on 7 October 2013 (50MW of firm capacity and 15MW of intermittent capacity by 2023). The BAU scenario assumes that firm capacity will be hydro and biomass (since both technologies are low cost, and there is resource available) and that intermittent capacity is wind, since it is more likely to win the tender compared to solar PV.

2.2.2 Stationary fuels

Compared to the BAU scenario, under the NSES scenario Belize would reduce fuel consumed by 19 percent by 2033. Fuel-related EE measures save BZ$261 million in net present value terms over the forecast period. These savings come from consuming less fuel and switching to lower cost or free energy sources.

Figure 2.4 shows the sustainable energy scenario for stationary fuel use compared to the BAU consumption projection.

Figure 2.4: Belize's NSES Scenario – Stationary Fuel Use (2012-2033)



The BAU fuels scenario is based on data collected during the course of the audit process (see Section 3.1) and MESTPU forecasts for stationary fuel use. The BAU scenario for fuels assumes that:

- Only currently used fuels are used in the future; introduction of new fuels is not assumed in the model
- Heavy fuel oil (HFO), diesel, and crude oil are used interchangeably in the industrial sector depending on availability and cost
- The residential sector consumption of LPG for hot water heating rises as living standards in Belize increase
- The audited facilities are representative of other industrial facilities throughout the rest of the country
- Current use patterns persist (and EE measures maintain their current penetration rate).

2.2.3 Greenhouse gas emissions

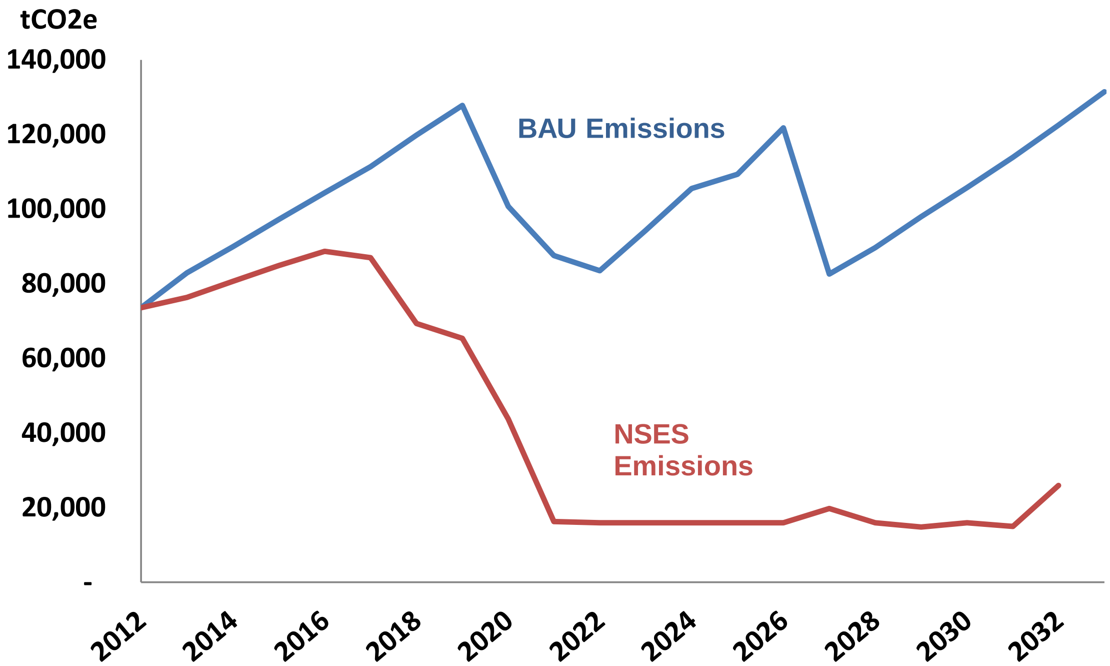
Sustainable energy can reduce Belize's carbon emissions by 2.4 million metric tons of CO_2e over the period 2013–2033. Under the NSES scenario, 1.4 million metric tons of CO_2e would be saved in the electricity sector and 1.0 million metric tons of CO_2e would be saved from use of stationary fuel EE measures.

These greenhouse gas emission reductions are achieved by:

- Reducing demand using EE measures in both the electricity and stationary fuels end uses
- Replacing fossil-fuel based energy with carbon-free domestic RE sources.

Figure 2.5 presents a comparison of CO_2 emissions from electricity in the BAU and NSES scenarios.

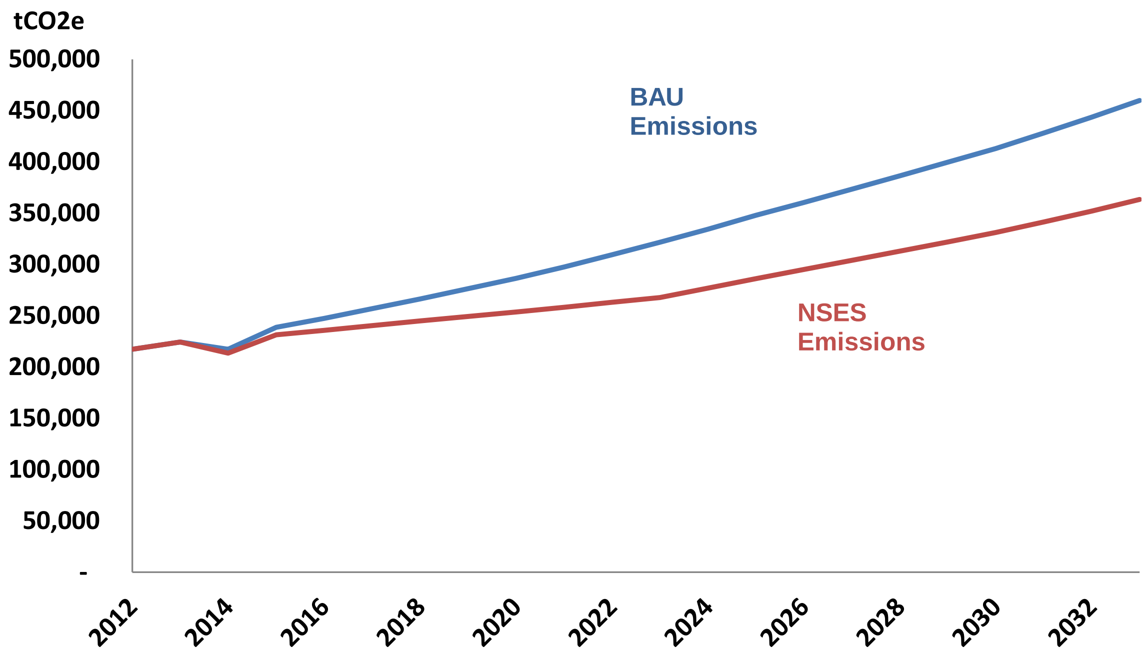
Figure 2.5: Comparison of Electricity Sector Emissions (2012–2033)



Notes: Assumes an emissions factor of 0.22 tCO_2 per MWh from CFE, 0.03 tCO_2 per MWh from bagasse, 0.8 tCO_2 per MWh from HFO, 0.9 tCO_2 per MWh of diesel; complete calculations are included in the accompanying Excel model.

Figure 2.6 compares NSES and BAU annual CO_2e emissions from stationary fuels.

Figure 2.6: Comparison of Stationary Fuel Emissions (2012-2033)

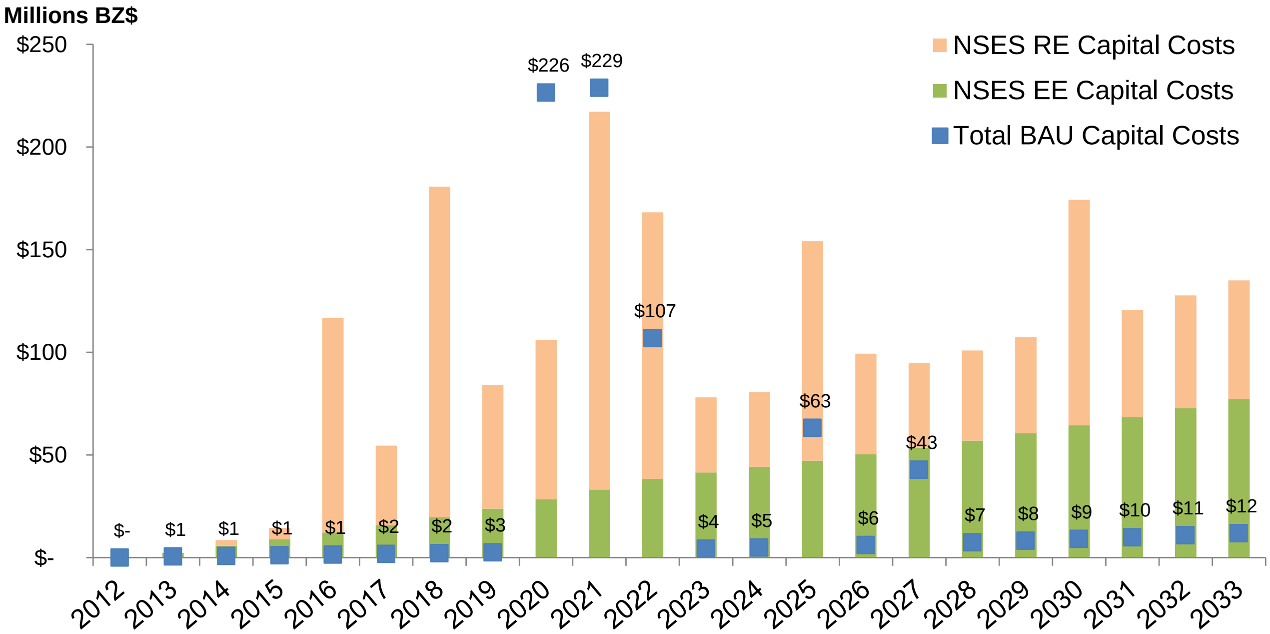


Notes: Assumes an emissions factor of 63 metric tCO_2e per TJ LPG, 74 tCO_2e per TJ diesel, 74 tCO_2e per TJ of crude oil, 77 tCO_2e per TJ of HFO, 2 tCO_2e per TJ of biomass.

2.2.4 Capital costs

The savings (both monetary and in GHG emissions) from the NSES scenario are generated by making upfront capital expenditure in renewable technologies and energy efficiency equipment and retrofits. Essentially, this means increasing upfront fixed costs to lower long-run variable costs. A comparison of capital expenditure between the BAU and NSES scenarios is presented in Figure 2.7 below.

Figure 2.7: Capital Cost Comparison



Note: Capital costs for the BAU scenario are shown as points, and NSES capital costs are shown as bars; see Table 3.4 and Table 4.4 for capital cost assumptions and Section 4.3 for installed capacity of RE.

In every year except for two (2020 and 2021), the NSES scenario has higher capital costs than the BAU scenario. There are two reasons for this:

- In each year of the NSES scenario, EE measures are implemented at a rate higher than in the BAU scenario; this requires capital expenditure
- In most years, the capital cost to expand generation capacity is higher for the NSES scenario. This is because rather than buying electricity from Mexico (which requires a low upfront capital investment), in the NSES scenario, Belize self-generates using new RE generation assets.

3 Belize's Energy Efficiency Potential

Belizean business, citizens, and government agencies could benefit from implementing a broad range of EE measures. Table 3.1 summarizes all of the EE measures recommended in this report for electricity, the sectors they apply to, and how they work.

Table 3.1: Recommended EE Measures for Electricity

EE Measure	Sectors	How the measure works
Replace leaky windows, doors/install weather sealing	RES, CO1, CO2	Reduces heat infiltration and air conditioning (AC) use
Paint walls and roofs with heat reflecting color; install heat-reducing window glaze	RES, CO1, CO2	Lower buildings' heat absorption, reducing AC use
Install window awnings	RES, CO1, CO2	Reduces heat infiltration and AC use
Replace lighting	RES, CO1, CO2	Replace current lights with models requiring lower wattage for same luminosity
Install efficient AC systems	RES, CO1, CO2	Replacing old AC units with more efficient models such as inverter split systems; these systems have the same cooling power, but lower wattage
Install roof insulation	CO1, CO2	Reduces heat transfer and AC use
Upgrade refrigeration equipment	RES, CO1, CO2	Replace leaky or inefficient refrigeration equipment with efficient models
Solar water heating	RES, CO1, CO2	Solar water heaters use the heat of the sun to warm water in a roof-mounted system; they can displace over 80 percent of electricity
LED street lights with photocells	Street lights	Replace lights with models requiring less wattage and providing better luminosity, less maintenance
Industrial refrigeration compressor efficiency	IND1, IND2	Takes waste heat away from the cooling equipment and can adjust load according to the equipment's needs moment by moment, saving energy
Motor and drive upgrades	IND1, IND2	Premium motors can run at variable speeds, only using the power required; synchronous belt drives slip less, wasting less power
Power factor correction	IND1, IND2	Installing capacitors to match real power supplied to the load to the apparent power of the circuit improves a facility's power factor and reduces the utility's load
Premium efficiency transformers	IND1, IND2	Reduce electricity conversion losses

Legend for sectors: *RES*— residential; *CO1* and *CO2*—small commercial and large commercial (includes government facilities in both categories); *IND1* and *IND2*—small industrial and large industrial

For a complete description of all the electricity EE measures see Appendix A.

Table 3.2 presents a summary of the recommended EE measures for stationary fuels.

Table 3.2: Recommended EE Measures for Stationary Fuels

EE Measure	Sectors	How the measure works
Solar water heating	Residential, commercial	Solar water heaters use the heat of the sun to warm water in a roof-mounted system; they can displace over 80 to 100 percent of LPG use
Efficient ovens and cooking equipment	Residential, commercial	Efficient units have less heat loss and burn fuel more efficiently, reducing LPG consumed by cooking in homes and restaurants
Industrial Heat Pumps	Industrial	Heat pumps on large industrial refrigeration systems reuse waste heat from compressors to pre-heat process loads
High efficiency industrial boilers	Industrial	High efficiency boilers have less heat loss and burn fuel more efficiently, lowering fuel use
Biomass boiler	Industrial	Replaces fossil fuel (crude oil, HFO, diesel) fired boiler with biomass fired boiler, avoiding fossil fuel use
Tankless gas hot water	Residential, commercial	Replace hot water heaters with tanks to on-demand tankless systems, eliminating storage losses from hot water cooling between uses
Improve efficiency of steam delivery for process heat	Industrial	Includes insulating steam lines, and repairing leaks to reduce energy loss, lowering fuel use
Set burner maintenance schedule for boilers and adjust equipment for efficiency	Industrial	Routine maintenance and equipment calibration ensures that boilers perform at maximum potential efficiency

This section presents how we select the measures listed in Table 3.1 and Table 3.2 as well as what their potential is in Belize.

- Section 3.1 presents a baseline for current electricity and stationary fuel consumption in Belize
- Section 3.2 explains how we screen EE measures
- Section 3.3 shows the long term penetration of the measures.

3.1 Baseline Energy Consumption

To determine the energy efficiency opportunities in Belize we use a baseline model of current energy consumption by end use and sector. This is based on data gathered during the audits performed by Young's Engineering and WSP. Our analysis also considers information on energy use from the 2010 census. This analysis indicates a significant opportunity to save fuel, electricity, and money by implementing energy efficiency measures in both the electricity sector and the stationary fuel use sector.

The audit process completed by Young's Engineering and WSP included 26 facilities in Belize (15 full audits, 10 walk through residential audits, and one walk through commercial audit). A summary of the 15 full audits is shown in Table 3.3. For complete audit reports for each facility, refer to Appendix C.

Table 3.3: Full Audits Performed by WSP and Young's Engineering

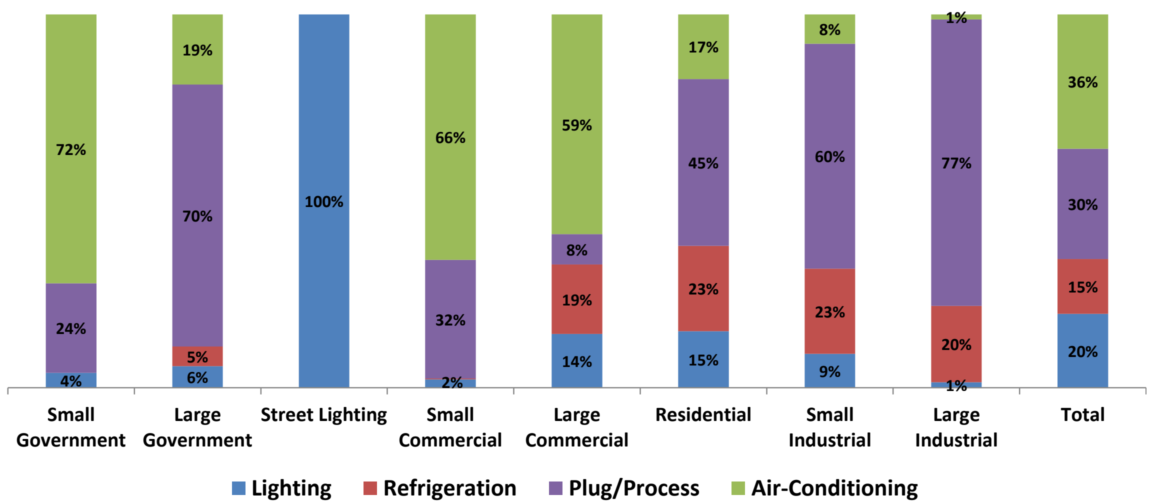
Category	Facility Name	Facility Description	Location
Industrial	Citrus Products of Belize Ltd.	Citrus fruit processing facility	Pomona Valley, Stann Creek
	Traveler's Liquors	Bottling facility	Belize City
	Quality Poultry Products Ltd.	Poultry processing facility	Spanish Lookout
	Running W Meats	Beef processing facility	San Ignacio
Hotel	The Villas at Banyan Bay	Full-service resort	San Pedro
	El Rey Hotel	Budget hotel	Belmopan
	Caves Branch Jungle Lodge	Full-service resort	Cayo District
	San Ignacio Hotel	Full-service hotel	San Ignacio
Government	MESTPU	Government offices	Belmopan
	Western Regional Hospital	Healthcare facility	Belmopan
	Customs and Excise Dept.	Offices	Belize City
	Holy Redeemer Lower School	Educational facility	Belize City
Office	Bowen and Bowen	Corporate headquarters	Belize City
	Young's Law Firm	Law office	Belize City
Retail	Publics Supermarket	Grocery supermarket	Belize City

Note: A full audit includes gathering information on all energy consuming equipment on site, interviewing employees about energy use patterns, and correlating past energy bills with equipment use to create a model of typical energy use.

The 10 walk-through residential audits locations were selected to represent a range of households, from households in the lowest 10 percent of electricity consumption, to the highest 10 percent of consumption. Residences in the Cayo, Corozal, and Belize districts were audited. We also completed one commercial walk-through audit of Celebrity restaurant in Belize City.

Based on full audits and walk-through audits, we can create a model of the end uses of electricity in Belize by sector. Figure 3.1 shows the breakdown of end use consumption by consumer type based on these audits.[2]

Figure 3.1: End Use of Electricity by Sector



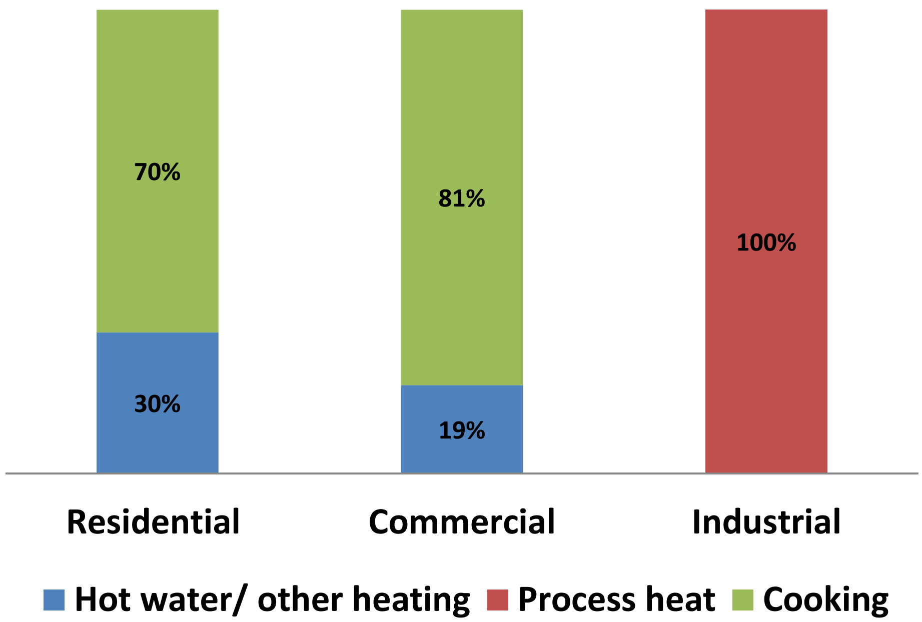
Overall, the largest end use of electricity in Belize is air conditioning. The commercial (large and small) and small government sectors all consume a significant amount of electricity for air conditioning.[3] The next largest source of consumption is plug/process end uses. This includes end uses such as home appliances, and commercial and industrial machinery. Plug/process electricity use is highest in the residential category, large and small industrial categories, as well as large government. Lighting is the third largest consumer of electricity overall; it is only the highest end use for the street lighting sector. Refrigeration represents the smallest of the end use categories, but still consumes a significant amount of electricity in the residential, small and large industrial, and large commercial sectors.

Using the audit data and information on fuel use from the MESTPU, we break down the use of stationary fuels by sector. Figure 3.2 below shows this breakdown by sector, only considering modern uses of fuel and excluding biomass for cooking and kerosene for lighting.

2 The consumer types follow BEL's billing categories, except that small government and large government have been separated from the commercial category. "Small government" and "small commercial" correspond to the BEL billing category "CO1." "Large government," and "large commercial," correspond to BEL billing category "CO2." "Small industrial" corresponds to "IND1," and "large industrial," corresponds to "IND2." "Residential," includes BEL billing categories "RLV," and "SOC."

3 The heavy electricity load demanded by air conditioners means that even if a minority of households own and use air conditioning equipment, it still consumes the largest share of electricity by end use.

Figure 3.2: End Use of Stationary Fuel by Sector



LPG for cooking is the primary use of fuel, with a smaller amount of LPG used for water heating. The commercial sector similarly uses most LPG fuel for cooking, with a small amount for water heating. As the Belizean economy grows we anticipate that water heating's share of end use will increase. All fuel use in the industrial sector (HFO, diesel, crude oil, and biomass) is for process heat—this means operating boilers to supply heat energy for productive uses.

3.2 Screening EE Measures

We screen EE measures in two steps:

- Selecting all measures that are appropriate for the end uses of energy reported by the audit process, and,
- Of the applicable measures, selecting all those that are economically and/or commercially viable.

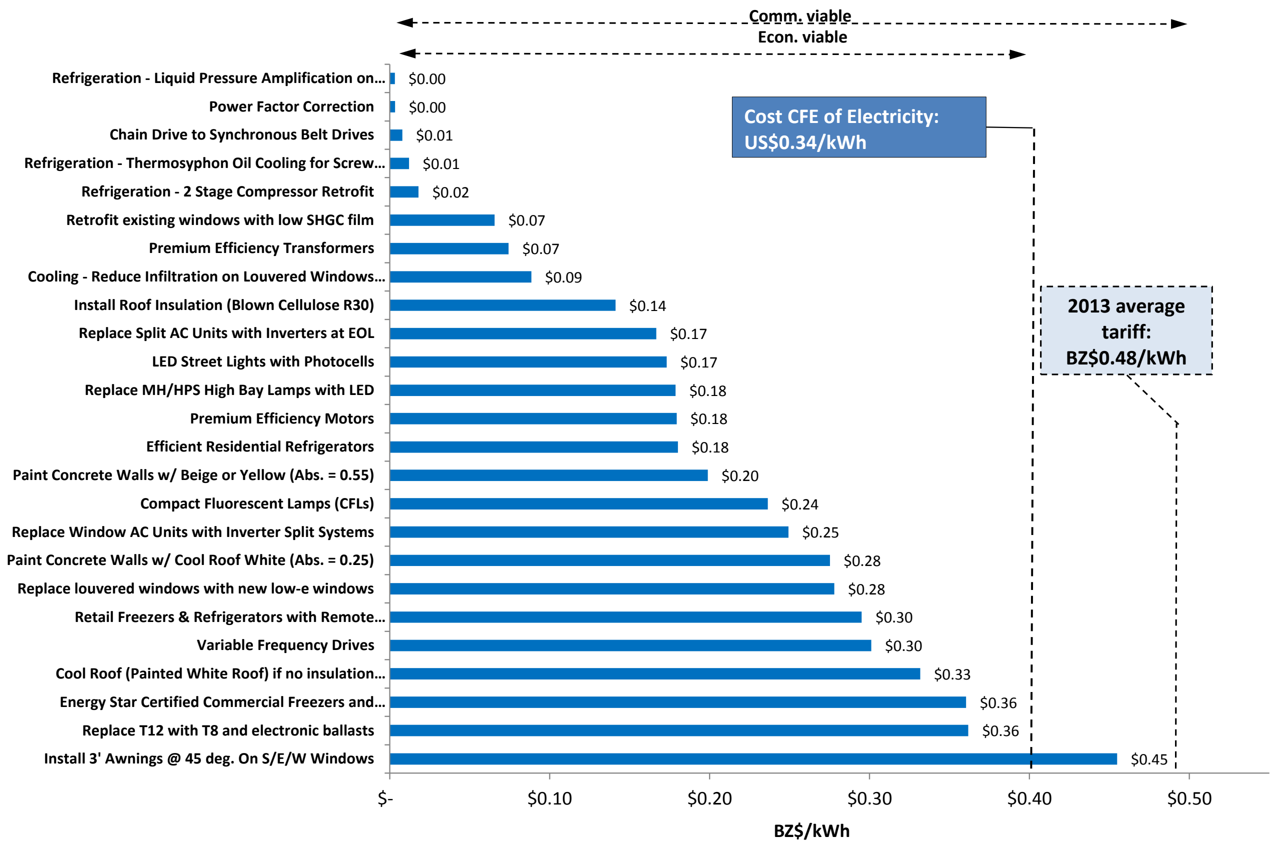
'Economically viable' measures are those for which the cost of saving a unit of energy is less than the cost of producing that unit of energy. Economically viable measures save money to Belize as a whole. For electricity, we assume the economic value of energy to be the wholesale price of the electricity that BEL purchases from CFE. For fuels, we assume the economic value of energy to be the cost of the fossil fuels that the energy saving measure displaces.

'Commercially viable' measures are those that cost less to implement than the retail cost of energy. Commercially viable measures save money to the person implementing them. All economically viable measures are also commercially viable. A few commercially viable measures are not economically viable: while they save money to the one implementing them, it would cost less to Belize to produce the electricity instead.

3.2.1 Electricity saving measures

Our analysis considers a number of electricity EE measures for appropriateness in Belize. All of the measures that are applicable to Belizean electricity use patterns and are economically and/or commercially viable are shown in Figure 3.3. They are compared to the relevant benchmarks.

Figure 3.3: Screening Electricity EE Measures



Note: Calculations based on cost estimates for each measure in Belize, amortized over the EE measure's lifetime at a discount rate of 6 percent (assuming concessional financing will be available)

Table 3.4 below presents a summary of cost and performance data for the electricity EE measures considered in our analysis.

Table 3.4: Performance of EE Measures and Cost Comparison

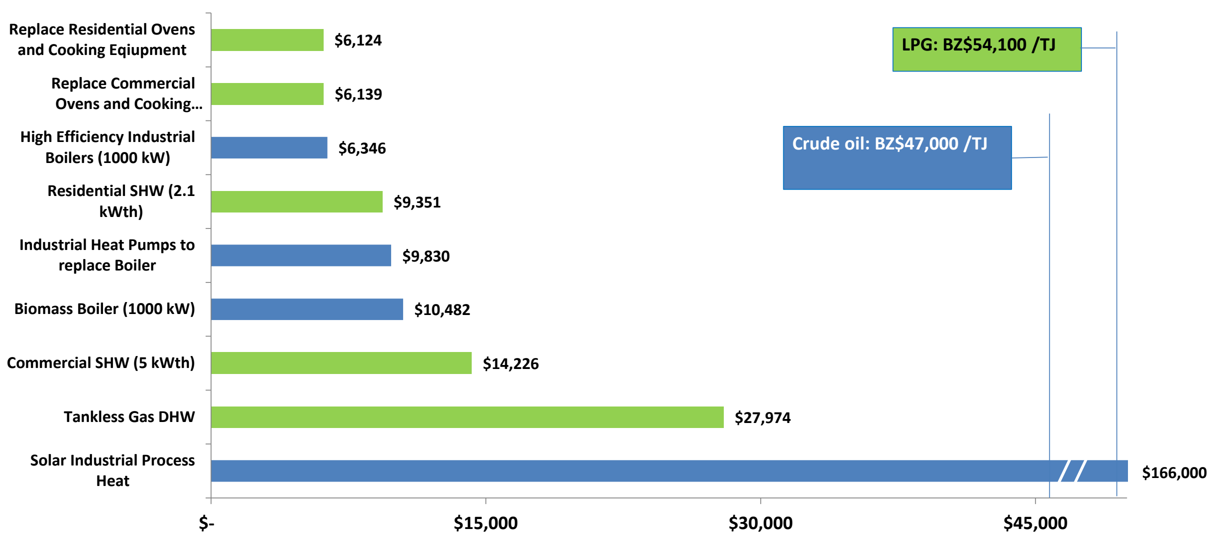
Energy Efficiency Measure	Applicable sectors*	Installed capacity	Lifetime	Savings vs. typical baseline	Savings vs. typical baseline	Simple Payback Period	Unit capital cost	Additional O&M costs**	Annualized capital cost	Annualized Capital cost recovery factor per kWh	O&M costs per kWh	Savings cost
		(kW)	(Years)	(%)	(kWh/year)	Years	(BZ$)	(BZ$/year)	(BZ$)	(BZ$/kWh)	(BZ$/kWh)	(BZ$/kWh)
Replace louvered windows with new low-e windows	RLV / CO1 / CO2	30.70	25	5%	3,032	7.0	$ (10,774)	$ -	$842.81	0.28	-	**0.28**
Cooling - Reduce Infiltration on Louvered Windows (or leaky doors/windows)	RLV / CO1 / CO2	32.28	25	2%	1,074	2.2	$ (1,215)	$ -	$95.05	0.09	-	**0.09**
Paint Concrete Walls w/ Beige or Yellow (Abs. = 0.55)	RLV / CO1 / CO2	30.95	15	3%	2,209	3.8	$ (4,265)	$ -	$439.14	0.20	-	**0.20**
Paint Concrete Walls w/ Cool Roof White (Abs. = 0.25)	RLV / CO1 / CO2	25.93	15	14%	8,388	5.2	$ (22,420)	$ -	$2,308.40	0.28	-	**0.28**
Install 3' Awnings @ 45 deg. On S/E/W Windows	RLV / CO1 / CO2	29.54	15	6%	3,975	8.6	$ (17,558)	$ -	$1,807.79	0.45	-	**0.45**
Compact Fluorescent Lamps (CFLs)	RLV / CO1 / CO2	0.02	5	75%	82	1.9	$ (81)	$ -	$19.41	0.24	-	**0.24**
Cool Roof (Painted White Roof) if no insulation present	RLV / CO1 / CO2	30.21	15	5%	3,480	6.3	$ (11,210)	$ -	$1,154.20	0.33	-	**0.33**
Replace Split AC Units with Inverters at EOL	RLV / CO1 / CO2	1.41	15	25%	937	3.2	$ (1,515)	$ -	$156.03	0.17	-	**0.17**
Replace MH/HPS High Bay Lamps with LED	CO1 / CO2 / IN1 / IN2	0.15	11	65%	1,927	2.9	$ (2,901)	$ (13.56)	$357.97	0.19	(0.01)	**0.18**
Replace T12 with T8 and electronic ballasts	CO1 / CO2	0.06	15	36%	69	6.9	$ (245)	$ (0.19)	$25.23	0.36	(0.00)	**0.36**
Retrofit existing windows with low SHGC film	CO1 / CO2	27.57	15	10%	6,058	1.2	$ (3,853)	$ -	$396.70	0.07	-	**0.07**
Install Roof Insulation (Blown Cellulose R30)	CO1 / CO2	30.46	20	5%	4,754	3.2	$ (7,695)	$ -	$670.92	0.14	-	**0.14**
Energy Star Certified Commercial Freezers and Refrigerators	CO1 / CO2	0.41	20	41%	2,976	8.1	$ (12,301)	$ -	$1,072.43	0.36	-	**0.36**
Retail Freezers & Refrigerators with Remote	CO1 / CO2	0.41	15	59%	5,124	5.6	$ (14,685)	$ -	$1,512.02	0.30	-	**0.30**
Replace Window AC Units with Inverter Split Systems	RLV / CO1 / CO2	1.06	15	51%	2,222	4.7	$ (5,379)	$ -	$553.84	0.25	-	**0.25**
Efficient Residential Refrigerators	RLV	0.06	15	32%	255	3.4	$ (446)	$ -	$45.95	0.18	-	**0.18**
LED Street Lights with Photocells	FRS	0.11	20	40%	456	6.3	$ (1,462)	$ (48.48)	$127.46	0.28	(0.11)	**0.17**
Refrigeration - Thermosyphon Oil Cooling for Screw Compressors	IND1 / IND2	119.46	15	27%	385,390	0.2	$ (44,851)	$ -	$4,618.01	0.01	-	**0.01**
Chain Drive to Synchronous Belt Drives	IND1 / IND2	32.42	15	6%	13,895	0.1	$ (1,060)	$ -	$109.18	0.01	-	**0.01**
Premium Efficiency Motors	IND1 / IND2	0.82	20	6%	393	4.0	$ (808)	$ -	$70.47	0.18	-	**0.18**
Variable Frequency Drives	IND1 / IND2	0.69	10	17%	596	1.4	$ (428)	$ 121.19	$58.15	0.10	0.20	**0.30**
Power Factor Correction	IND1 / IND2	51.02	20	21%	85,192	0.4	$ (3,229)	$ -	$281.49	0.00	-	**0.00**
Refrigeration - Liquid Pressure Amplification on	IND1 / IND2	400.00	15	20%	876,000	0.1	$ (26,619)	$ -	$2,740.79	0.00	-	**0.00**
Refrigeration - 2 Stage Compressor Retrofit	IND1 / IND2	165.00	20	18%	294,000	0.4	$ (60,594)	$ -	$5,282.87	0.02	-	**0.02**
Premium Efficiency Transformers	IND1 / IND2	212.32	20	2%	28,641	1.7	$ (24,415)	$ -	$2,128.62	0.07	-	**0.07**

Note: Savings from window upgrades, roof and wall painting, and window awnings assumes implementation in air conditioned facilities.

3.2.2 Stationary fuel efficiency measures

Fuel efficiency measures reduce fuel consumption, switch fuels to a more efficient fuel source, or replace a fossil fuel with a renewable resource. We review fuel saving measures by first screening for applicability in Belize. This is based on the fuel uses we observed in the audit process, as well as fuel end use information analysis provided to us by the MESTPU. Next we screen fuel efficiency measures for economic and commercial viability. The benchmark for viability is the cost of LPG for commercial and residential sector measures and the cost of crude oil for the industrial sector measures. All the measures except for industrial solar water heating are economically and commercially viable.

Figure 3.4: Screening Liquid Fuel EE Measures



Note: The cost of each measure is amortized over that measure's lifetime at a 6 percent discount rate.

3.3 Long-term Uptake of EE

The NSES scenario forecasts that EE measures for fuel and electricity reach a 75 percent penetration in their first 10 years of implementation, and 90 percent penetration by the end of the forecast period (2033). This means that at the end of the forecast period, 90 percent of energy consumers who could use the individual EE measures adopt them. This assumption is reasonable, given a forecast period of 20 years and a government program to increase the use of EE measures.

To generate the economy-wide projections for electricity we follow a three step process:

- We assemble measures into a package for a typical consumer
- We assume a number of typical consumers per sector
- We assume that by 2030, 90 percent of Belizean energy consumers would adopt the package of EE measures for a typical consumer in their category

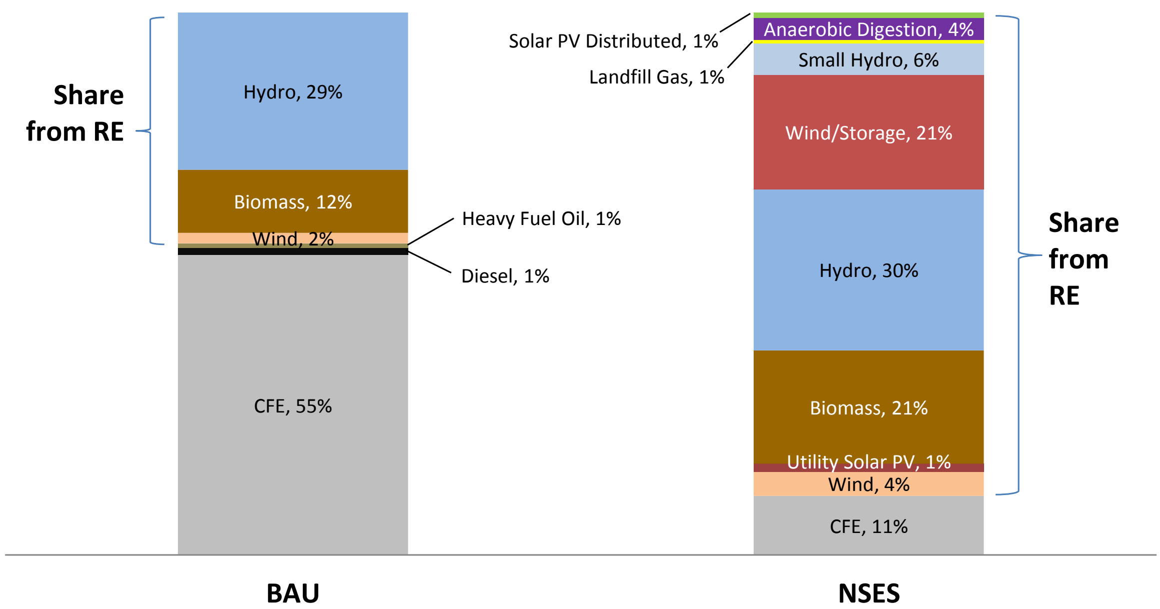
For stationary fuel use we follow a similar process.

4 Belize's Renewable Energy Potential

Belize already has a significant share of RE in its energy matrix, generating over 50 percent of electricity from RE in 2012—but it could have even more. In the NSES scenario, 89 percent of Belize's electricity comes from RE by 2033, compared to just over 40 percent in the BAU projection.

Figure 4.1 shows a comparison of the share of generation from RE in 2033 for the BAU scenario and the NSES scenario. Each of the colors represents electricity from a different source.[4]

Figure 4.1: Comparison of Total Generation Share from RE, 2033



Reaching a penetration rate of nearly 90 percent RE will require that Belize uses a variety of RE technologies. Table 4.1 presents a summary of these technologies and their potential.

Table 4.1: Recommended RE Technologies for Belize

Technology	How it Works	Summary of the Technology's Potential for Belize
Landfill gas	Combustible gasses from landfill sites are captured and combusted to run a turbine	Belize's waste stream is unused for electricity and could be tapped for use by a small plant (< 2MW)
Small hydro	Small hydro turbines (1-5MW) are employed on waterways too small for conventional hydro technology	Belize has a number of untapped small hydro sites

[4] This section does not consider the possibility of renewable energy-based fuels for transport.

Technology	How it Works	Summary of the Technology's Potential for Belize
Anaerobic digestion	Agricultural waste is put in a digester reactor which captures gas; gas is then combusted to operate a turbine	Belize has agricultural production that could power anaerobic generation
Hydro	Conventional hydroelectric dams (larger than 5MW), similar to the ones in operation in Belize	Belize has several promising hydro sites it could develop
Biomass	Bagasse and forestry wastes are combusted to power a steam turbine	Sugar and forestry industry waste could be an important source of generation
Wind	Wind turns the turbines, generating electricity	Belize has several sites with wind generation potential, though most of the country is not suitable for wind generation
Wind with pumped hydro storage	Wind turbines generate electricity which is supplied to the grid for immediate consumption, or used to pump water behind a dam to be used later to generate power via the dam	Belize has a site suitable for pumped hydro storage, as well as several windy sites appropriate for commercial scale wind
Solar PV	Solar energy is converted to electric energy using PV panels	Belize has a decent solar resource, and it does have available land suitable for solar arrays; existing buildings could also host distributed generation

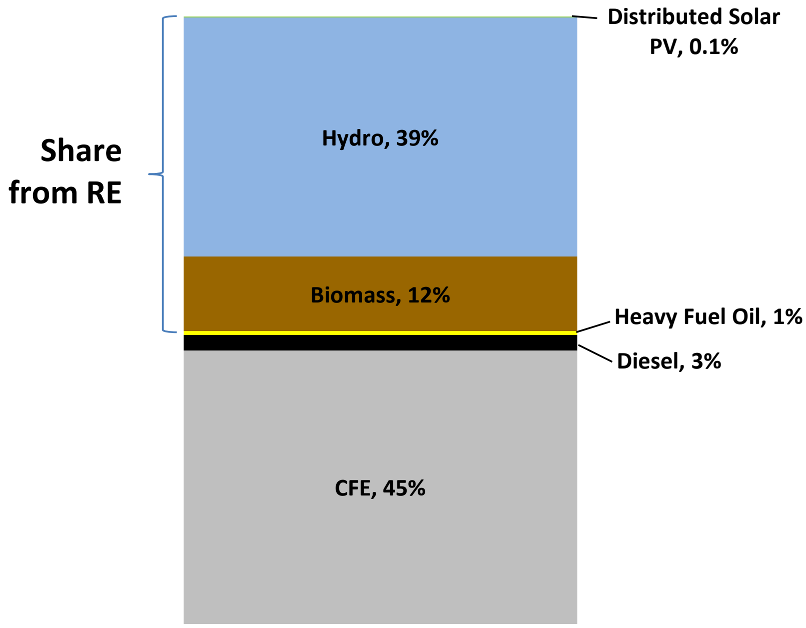
This section presents:

- The baseline of RE generation (Section 4.1)
- How we screen RE technologies for Belize (Section 4.2)
- The long-term potential for RE (Section 4.3)
- The role of off-grid RE (Section 4.4).

4.1 Baseline of RE Generation in Belize

In 2012, 52 percent of Belize's electricity came from renewable resources, mainly hydro and biomass. A small amount of electricity was also generated by the 480kW solar PV plant at the University of Belize. The balance was purchased from CFE, or generated from diesel and HFO. Figure 4.2 presents the 2012 baseline of electricity generation (by source) in Belize, as well as showing electricity purchases from CFE.

Figure 4.2: 2012 Annual Generation by Source (GWh)



Source: BEL 2012 Annual Report

Table 4.2 presents the existing sources of grid-connected electricity in Belize, their capacity, and their total 2012 generation.

Table 4.2: BEL Sources of Electricity

Plant/Source	Type	Capacity (MW)	2012 Generation (MWh)
BEL gas turbine	Diesel	21.5	7,200
BEL diesel generators	Diesel	4.4	6,300
Hydro Maya	Hydro	3.4	9,600
Mollejon	Hydro	27	107,000
Chalillo	Hydro	7.3	19,700
Vaca	Hydro	19	72,300
BELCOGEN	Bagasse	13.5	64,500
BAL	HFO	15	3,500
CFE	Transmission	50	237,800

Source: BEL

4.2 Screening RE Technologies

We screen RE technologies for both technical viability and economic/commercial viability. For each technology, we ask the following questions:

- Does a renewable resource of sufficient quantity and quality exist?
- Is the RE technology mature, meaning, is it an established commercially operated technology?
- Can the technology generate electricity at or below the cost of the relevant economic and commercial benchmarks?

Sections 4.2.1 and 4.2.2 present this screening process detail, as well as the results of the screening.

4.2.1 Screening for technical viability

'Technical viability' means that a renewable energy resource is available in sufficient quantity and quality to provide electricity at a commercial scale, and that the technology to exploit that resource is proven. To evaluate the technical viability of renewable energy resources we first completed a literature review of existing resource assessments for Belize. We also spoke with Government ministries and private companies to get information on renewable energy resources in Belize. We then evaluated the technological maturity of the different renewable energy technologies based on our team's experience in other markets.

Based on our evaluation, we assign each technology a score between zero and two for resource availability, as well as for the maturity of the technology.[5] Technologies that receive a combined score of three or four are screened in to the NSES scenario. Technologies with scores less than three are screened out. If those technologies become more mature, or if a better underlying resource is found in Belize, the screened out technologies should be reconsidered in the future.

Table 4.3 presents a summary of our technical screening of renewable energy technologies in Belize. For more information on each of the technologies, see Appendix B.

Table 4.3: Technical Screening Summary of RE Technologies

Technology	Resource Availability (0-2)	Tech. Maturity (0-2)	Overall Assessment	In or out?
On-Shore Wind	2	2	Several sites with good wind speeds; mature technology	In
Off-Shore Wind	1	1	Sites with good wind speeds are far offshore; technology still maturing	Out
Distributed PV	1	2	Decent solar resource; relatively mature technology, still experiencing cost declines	In
Utility Scale PV	1	2	Decent solar resource (4.5 to5.5 kWh/meter sq. per day); relatively mature technology,	In

[5] A resource availability score of zero indicates that the resource is not available in any significant quantity or quality. A score of one indicates that the resource is readily available in quantity or quality but not in both. A score of two indicates that the resource is readily available in quantity and quality. For technological maturity, a score of zero indicates that the technology is not commercially proven and only exists at a conceptual or pilot stage; a score of one, that the technology is in use commercially, but still has potential for significant improvements. A score of two indicates that the technology is unlikely to experience major improvements in the short to medium term.

Technology	Resource Availability (0-2)	Tech. Maturity (0-2)	Overall Assessment	In or out?
			still experiencing cost declines	
Concentrated Solar Power	1	1	Marginal resource availability; technology in commercial operation, but significant improvements and cost reductions expected.	Out
Waste Incineration	0	2	Mature technology; insufficient waste quantity	Out
Landfill gas	1	2	Small resource, but sufficient for power generation; mature technology	In
Biomass Power[6]	2	2	Good resource availability; proven technology in Belize	In
Small Hydro (1-5MW)	2	2	Good resource availability; proven technology	In
Large Hydro (above 5MW)	1	2	Several sites still undeveloped; proven technology in Belize	In
Geothermal	0	2	Mature technology, no resource identified	Out
Ocean thermal energy conversion	1?	0	Resource quality unstudied; immature technology	Out
Ocean wave	1?	0	Resource quality unstudied; immature technology	Out

4.2.2 Screening for economic and commercial viability

The NSES scenario only includes the implementation of economically and/or commercially viable technologies. In the simplest sense, renewable power is economically viable when the cost of power from renewables is less than the cost of power it replaces. However, an adequate and comprehensive evaluation needs to consider the following factors: whether the renewable generation is firm or not, whether the renewable generation is distributed (at the user premises) or utility scale, and the cost of competing supply.

Firm or non-firm renewable generation

Many renewable generation technologies are non-firm. That is, unlike a conventional generation unit, they cannot be switched on at will. Rather, they only produce power when the renewable energy source is available. Wind turbines only produce power when the wind is blowing. Solar PV only makes electricity when the sun is shining.

When non-firm technologies are installed, it is necessary to also have another, firm generation technology available as back-up, so that demand for power can be met even when the renewable generation is not operating. Typically in Belize this power could come from

6 This assessment is based on biomass for direct power generation; producing biomass for direct generation is more efficient than producing and burning biofuels. See Appendix B for details.

CFE. It follows that non-firm technologies—including wind and solar PV—should be evaluated according to whether the cost of the power they produce is more or less than the cost of the power from CFE. If they generate at a cost less than power from CFE, they are economically viable.

Distributed or utility scale renewable generation

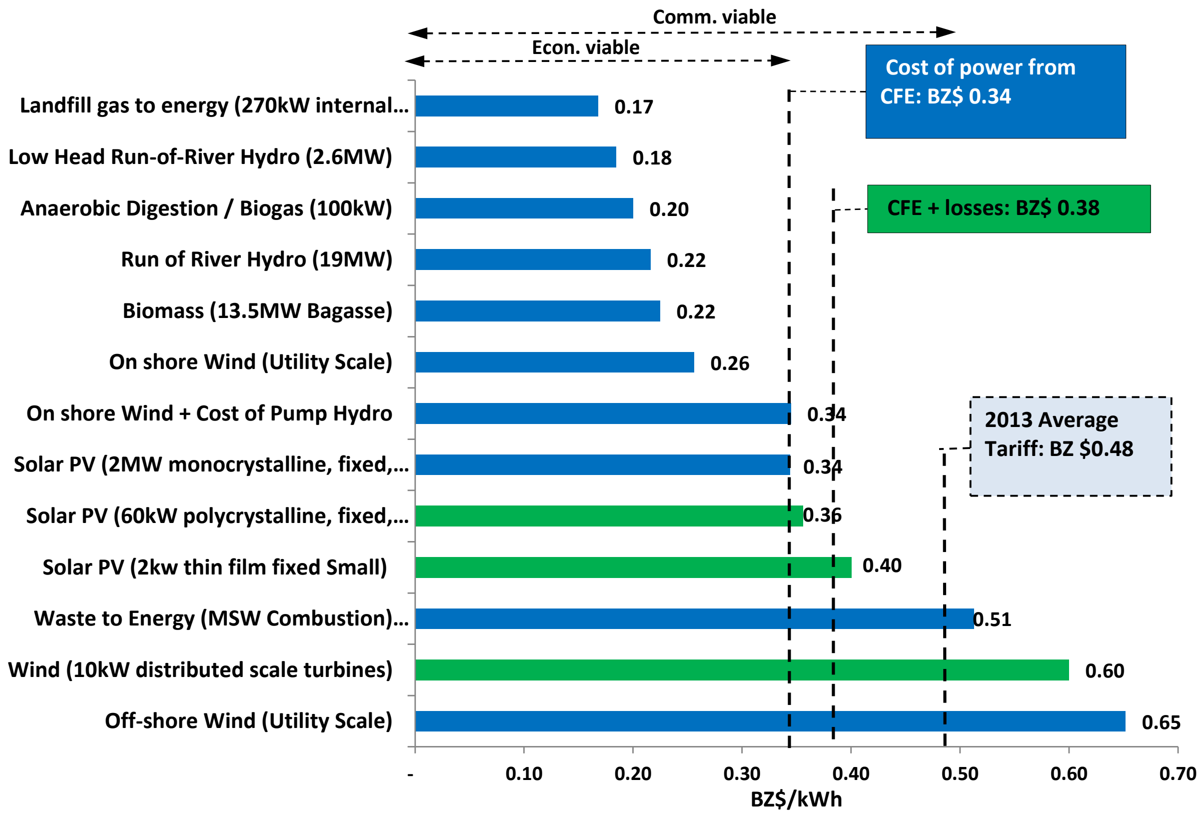
While conventional power plants are installed on a dedicated site and supply to consumers over the transmission and distribution grids, many small scale renewables can be installed at the customer premises. These technologies can be referred to as 'distributed' generation because they are distributed over the network at consumer premises. The relevant intermittent distributed generation technologies are solar PV, and small scale wind technologies.

Because these technologies generate at the customer premise, they compete against the retail tariff. Customers will choose these technologies if they can supply power at a lower cost (over time) than the price of power from the grid. For this reason, Figure 4.3 shows the average retail tariffs, so that distributed generation costs can be benchmarked against retail tariffs.

From an overall economic or social welfare perspective, however, the relevant benchmark is the variable cost of generation grossed up for losses. This is because customers using distributed generation still rely on the utility system to provide back-up power when the distributed unit is not operating, and also (potentially) to distribute excess power to other customers. The variable cost is grossed up for losses to account for the fact that the distributed generation avoids the transmission losses faced by utility scale generation. In Belize the variable cost of generation is the cost of electricity from CFE since it provides backup power when domestic sources are unavailable.

Figure 4.3 presents a summary of our screening for economic and commercial viability. Each technology's levelized cost of power is compared to benchmarks for economic and commercial viability (in BZ$).

Figure 4.3: Screening RE Technologies



Note: Cost assumptions are based on similar RE projects in the LAC region; capital costs are amortized over the plant life at a discount rate of 10 percent. Solar PV levelized costs presented are for the 'low price' scenario (described below).

To develop the levelized cost of generation for each technology we:

- Use information on capital and operating costs for similarly sized projects in the region, including similar projects operating in Belize, when possible
- Assume a capacity factor for each plant based on the technology and the characteristics of the renewable resource (a capacity factor is the ratio of a power plant's actual output compared to its potential output over a period of time)
- Amortize capital costs (assuming a 10 percent cost of capital) over the plant's lifetime and divide the annual cost over total annual generation (in kWh)
- Divide annual operations and maintenance (O&M) costs over the plant's annual generation
- Combine the amortized capital costs and O&M costs to forecast a levelized cost of electricity per kWh (shown in Table 4.4 below)

Table 4.4: Performance of RE Technologies and Cost Comparison

Technology	Installed capacity	Unit Capital Cost	O&M costs per year	Vari. O&M (Incl. Fuel)	Lifetime	Capacity Factor	Output per kW capacity per year	Total system cost	Annualized capital cost	Annual O&M costs	Annual system output	Capital cost recovery factor	O&M cost per kWh	LRMC	LRMC
	kW	US$/kW	US$/kW/yr	US$/MWh	Years	%	kWh/kW/yr	US$	US$/yr	US$/yr	kWh/yr	US$/kWh	US$/kWh	US$/kWh	BZ$/kWh
Landfill gas to energy (270kW internal combustion)	270	$ 4,000	$ 149		20	85%	7,446	$ 1,080,000	$ 126,856	$ 40,208	2,010,420	$ 0.06	$ 0.02	$ 0.08	$ 0.17
Low Head Run-of-River Hydro (2.6MW)	2,600	$ 2,735	$ 119		15	50%	4,380	$ 7,111,158	$ 732,184	$ 308,162	11,388,000	$ 0.06	$ 0.03	$ 0.09	$ 0.18
Anaerobic Digestion / Biogas (100kW)	100	$ 5,000	$ 150		20	85%	7,446	$ 500,000	$ 58,730	$ 15,000	744,600	$ 0.08	$ 0.02	$ 0.10	$ 0.20
Run of River Hydro (19MW)	19,000	$ 3,400	$ 150		25	56%	4,906	$ 64,600,000	$ 7,116,857	$ 2,850,000	93,206,400	$ 0.08	$ 0.03	$ 0.11	$ 0.22
Biomass (13.5MW Bagasse)	13,500	$ 4,400	$ 22		25	52%	4,555	$ 59,400,000	$ 6,543,983	$ 297,000	61,495,200	$ 0.11	$ 0.00	$ 0.11	$ 0.22
On shore Wind (Utility Scale)	100,000	$ 2,210	$ 40	$ -	20	27%	2,365	$ 221,000,000	$ 25,958,577	$ 4,000,000	236,520,000	$ 0.11	$ 0.02	$ 0.13	$ 0.26
Solar PV (2MW monocrystalline, fixed, utility scale)	2,000	$ 1,750	$ 30	$ -	20	16%	1,382	$ 3,500,000	$ 411,109	$ 60,000	2,764,656	$ 0.15	$ 0.02	$ 0.17	$ 0.34
Solar PV (60kW polycrystalline, fixed, commercial)	60	$ 2,450	$ 30	$ -	20	16%	1,382	$ 147,000.00	$12,816.13	$ 1,800.00	82,940	$ 0.15	$ 0.02	$ 0.18	$ 0.36
Solar PV (2kw thin film fixed Small)	2	$ 2,800	$ 30	$ -	20	16%	1,382	$ 5,600.00	$ 488.23	$ 60.00	2,765	$ 0.18	$ 0.02	$ 0.20	$ 0.40
Waste to Energy (MSW Combustion) 7.5MW	7,500	$ 12,300	$ 566	$ (4.02)	25	85%	7,446	$ 92,250,000	$ 10,163,005	$ 4,019,061	55,845,000	$ 0.18	$ 0.07	$ 0.25	$ 0.51
Wind (10kW distributed scale turbines)	10	$ 6,000	$ 44	$ 0.02	20	22%	1,910	$ 60,000	$ 5,231	$ 440	19,097	$ 0.27	$ 0.02	$ 0.30	$ 0.60
Off-shore Wind (Utility Scale)	100,000	$ 6,230	$ 74.00	$ -	25	27%	2,356	$ 623,000,000	$ 68,634,709	$ 7,400,000	235,644,000	$ 0.29	$ 0.03	$ 0.32	$ 0.65

Note: The utility scale project discount rate is 10 percent; distributed scale discount rate is 6 percent (assuming concessional financing will be available); PV price information is from the 'low' capital cost scenario presented below; the calculation for wind with storage is presented in Appendix B.

Solar PV

Current solar PV prices in Belize are above global norms. With effective procurement policies and economies of scale they could be lower. To provide context for solar PV costs in Belize, we model actual PV levelized costs observed in Belize. We also model three price scenarios for solar PV (based on our experience in other markets) and compare them to the relevant benchmarks.

The cost of solar PV modules has declined rapidly in recent years, from around US$4.00 per watt in 2008 to below US$1.00 per watt in 2012.[7] Despite these fall in prices, the observed price of solar PV generation in Belize remains high compared to international benchmarks. There are few data points for solar PV generation in Belize; we base our analysis primarily on quotes for PV systems from Pro Solar, a Belizean installer.[8] We also include data on the University of Belize's 480kW PV system for comparison.[9] Both systems generate at a cost well above the average electricity tariff benchmark.

The high cost of PV in Belize is primarily due to the high cost of system components. A quote from Pro Solar indicates solar PV module costs of US$2.00 per watt (compared to the US$1.00 per watt figure presented above). The difference in inverter costs is less significant; the quoted Pro Solar inverter cost is about seven percent higher than the price for a comparable inverter in the United States.[10]

Labor costs are also higher in Belize. The quote from Pro Solar indicates labor costs of US$0.75 per watt of residential PV capacity installed. The comparable cost is US$0.49 per watt installed in the United States.[11]

We model three PV price scenarios below: low, medium, and high capital cost scenarios. We consider these price scenarios to be indicative of what solar PV should cost in Belize, rather than the observed prices from Pro Solar and the University of Belize system. These scenarios and the observed prices in Belize are presented in Figure 4.4.

[7] Bazilian, Morgan, et al. "Re-considering the Economics of Photovoltaic Power." Bloomberg New Energy Finance. 2012.

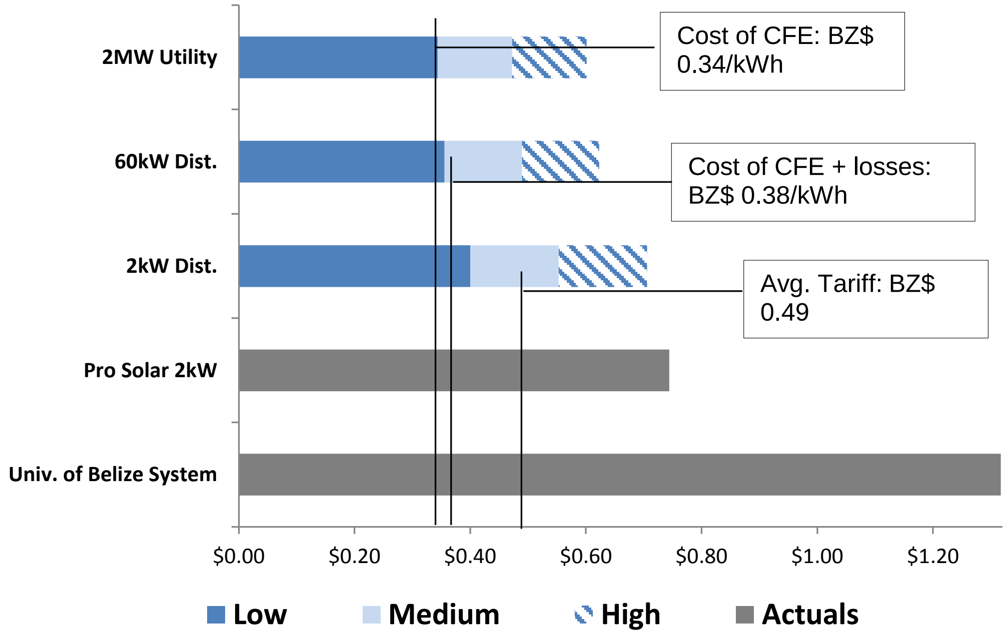
[8] Based on a quote we requested for a 2kW grid-connected system.

[9] The University of Belize system costs are significantly higher than prices in other markets.

[10] US$1,600 in Belize, compared to US$1,500 in the United States, based on the price of a 'Sunny Boy' 2500 Watt inverter sold at Eco Distributing, a US online retailer.

[11] Ardani, Kristen, et al. "Non-Hardware ('Soft') Cost-Reduction Roadmap for Residential and Small Commercial Solar Photovoltaics 2013-2030." National Renewable Energy Laboratory. August, 2013.

Figure 4.4: Solar PV Cost Scenario Comparisons



Note: The 'low' price scenario is equivalent to 70 percent of the 'medium' price scenario; the 'high' price scenario is equivalent to 130 percent of the medium price scenario. A discount rate of 10 percent was used for utility scale PV projects and a discount rate of six percent was used for distributed generation projects.

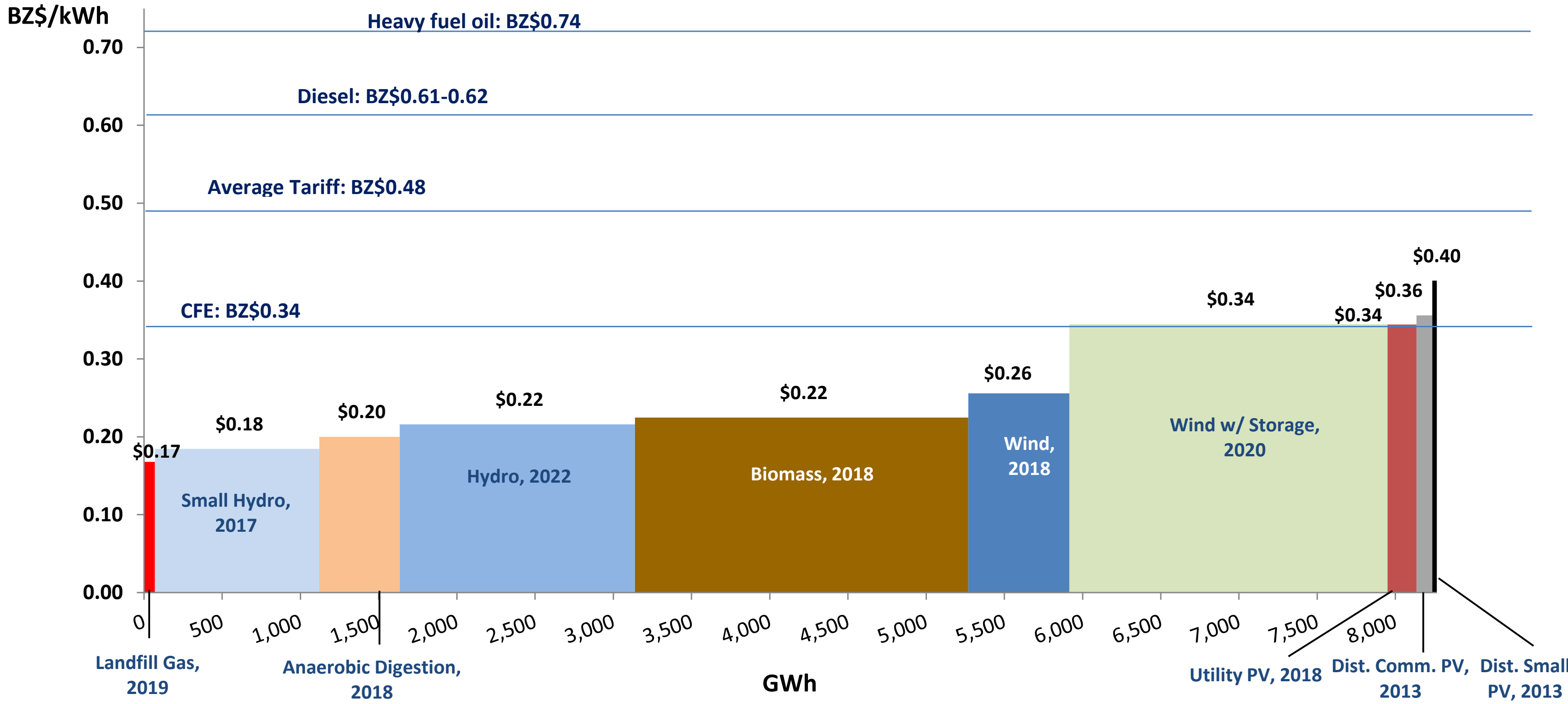
Of the three price scenarios, only the low price scenario generates electricity below the relevant benchmarks. This means that it may be possible to install solar power that generates at a viable price, but this will depend on receiving very competitive offers.

4.3 Long-term Uptake of RE

In the NSES scenario, total generation from RE rises from 52 percent of generation in 2012 to 89 percent by 2033. Reaching this target depends on developing all of the technically and economically viable RE resources in Belize.

Figure 4.5 below shows the long-term generation potential of the recommended technologies (on the X axis), their costs of generation (on the Y axis), and the year in which the first plants come online. The horizontal lines running parallel to the X axis show the competing costs of generation (including the benchmarks from Figure 4.3).

Figure 4.5: Viable RE Technologies by Cost and Total Generation



Note: the figure above includes generation from new RE assets that are also included in the BAU scenario.

Figure 4.5 is based upon the following assumptions (for complete descriptions of the technologies, see Appendix B):

- **Landfill gas**—a landfill gas plant is assumed to operate at the landfill site that serves Belmopan, Belize City, and San Ignacio. The waste volume at this site is large enough to support a small plant that grows in size as more waste accumulates.[12] The plant grows to 1.7MW by the end of the forecast period
- **Small hydro**—for the purposes of this report we define small hydro projects as run of river low head projects less than 3MW in size. A combination of plants equal to 5MW is assumed to come online each year in 2017, 2018, and 2019. Small hydro plants would operate at some of the sites identified in the 2006 Elektrowatt-Ekono technical report on Belize's hydro potential; we also assume that several other similar sites will be identified
- **Anaerobic digestion**—these plants are small, 100kW to 300kW, and distributed among agricultural of food packing sites. A combination of plants equal to 1MW come online in 2017 and more plants are added over the forecast period, reaching a total of 6MW by 2033. This growth is due to the growth of the associated waste producing industries
- **Hydro**—a 15MW plant at the Mopan River Cascade site comes online in 2022, and an 8.4MW plant comes online at Vaca Falls in 2025. These plants are based on sites identified in BEL's 2009 expansion plan and the 2006 Elektrowatt-Ekono technical report. The Mollejon hydro plant is also upgraded in 2020, increasing installed capacity from 27MW to 32MW. These hydro plants have capacity factors comparable to existing BECOL hydro assets
- **Biomass**—the first biomass facility to come online is a 4.3MW facility fed by forestry industry residues in 2018. In 2021, an 18MW biomass plant comes online. We assume the growth of the sugar industry and/or cultivation of energy crops to supply this plant (for example, *Arundo Donax,* a fast growing grass energy crop). This plant is upgraded to 23MW in 2030 as sugar or energy crop production increase. Both plants are assumed to have similar operating characteristics to the BELCOGEN plant, though cleaner and more cost effective technologies may be available in the future
- **Wind**—12MW of wind comes online in 2018 in the NSES scenario. This capacity increases to 15MW in 2020, 18MW in 2025, and 20MW in 2030. The capacity factor of all wind is assumed to be 27 percent. The amount of wind and solar PV allowed on the grid is limited to 20 percent of hourly peak demand[13]

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[12] Inter-American Development Bank. "Waste Generation and Composition Study for the Western Corridor, Belize C.A. 2056/OC-BL: Final Report." May 2011

[13] Because solar and wind plants generate at different times of day, the actually installed capacity of solar and wind is slightly above 20 percent of *annual* peak demand, even when it matches the 20 percent of *hourly* peak demand requirement.

- **Wind with pumped hydro storage**—a 7MW pumped hydro storage facility comes online in 2020 at the Chalillo 3 site.[14] This allows the development of 100MW of wind power to use the storage facility (this is in addition to the wind mentioned above).[15] 30MW of wind comes online in 2020, increasing to 40MW in 2023, 50MW in 2025, 80MW in 2028, and 100MW by 2031
- **Utility solar PV**—5MW of utility scale solar PV comes online in 2018, growing to 7MW in 2023, 10MW in 2026, and 12MW in 2030. As for wind (without storage), solar PV is an intermittent source of electricity. Wind and solar capacity without storage are limited to 20 percent of peak load
- **Distributed solar PV**—a total of 385kW of distributed PV come online in each year of the forecast period; 350kW from larger commercial systems (20 to 60kW) and 35kW from residential systems (smaller than 2kW each). These systems are also subject to the 20 percent of peak load restriction on all intermittent generation technologies, since they are interconnected to the main grid. By 2033, 10MW of distributed PV are installed in the NSES scenario.

The long-term uptake of utility-scale RE also assumes that the projects will receive environmental approval.

4.4 Evaluating Belize's Renewable Energy Export Potential

The NSES sets the objective of Belize being a net energy exporter by 2020. However, the RE resource assessments in Belize and its neighbors and the regional demand profiles suggest that RE development in Belize should be focused primarily on serving domestic load in the short to medium term. Solar PV is likely the primary RE technology available for export from Belize. Yet, it would not be cost competitive with wholesale electricity prices in neighboring markets, and so should not be the primary focus of energy policy.

Belize should still pursue medium- to long-term projects to strengthen interconnection transfer capacities with CFE and SIEPAC. These interconnections would allow Belize to greatly benefit from reliability and efficiency, simply by being able to trade electricity as needed with its neighbors. Such trades can help avoid service interruptions during emergency operating conditions. At the same time, they can also allow Belize to exchange electricity when it is economically justified, and thus save ratepayers money; if Belize's energy export potential is higher in the future it could use the interconnections to export. The energy exports shown in the NSES scenario assume such interconnections.

We present below our process for evaluating Belize's export potential: Section 4.4.1 provides a screening of the export potential for various RE technologies; in Section 4.4.2, we screen the markets to which Belize's RE generation could be exported. We conclude in Section 4.4.3 by identifying the next steps to facilitate electricity exports to neighboring markets.

[14] This would require flooding an area around the river to create a reservoir area. Detailed environmental assessments have not yet been completed to fully detail the impacts.

[15] The 100MW of wind are calculated using an optimization model based on the size of the pumped hydro storage site, the existing generation technologies in use in Belize, and the daily load profile.

4.4.1 Screening for RE technologies for export

Solar PV is the RE technology that is most likely to be available for export from Belize. This is based on our energy sector model, in which we screen for various RE technologies that could be exported under the NSES scenario. This scenario represents an aggressive expansion of RE generation capacity, which is designed to meet the growth in Belize's electricity demand. The results of the NSES scenario show that from 2021 to 2028, Belize could export between 2 and 6 percent of net generation to CFE and/or to SIEPAC.

In Table 4.5, we screen all of the economically viable RE technologies recommended under the NSES scenario. Our screening relied on two criteria:

- Only those technologies which provide non-firm capacity would be considered for export. This is because under the NSES scenario, all potential firm capacity must be utilized to meet Belize's demand forecast
- The lowest cost power would be dispatched first for domestic demand; after meeting domestic demand remaining power could be exported.

Table 4.5: Screening for Renewable Energy Exports

Technology	Export Candidate?	Firm Capacity?	Rationale
Solar PV	Yes	No	The technical potential of solar PV is higher than the potential included in the NSES; if Belize wanted to dedicate more of its land area to PV arrays, it could
On-Shore Wind	No	No	The NSES scenario exploits all the technical wind potential for domestic consumption, leaving little for export
On-Shore Wind w/ Storage	No	Yes	Adding pumped hydro storage to wind makes it a firm capacity source. Production from this source is likely to cover domestic demand
Landfill Gas	No	Yes	Landfill gas is a firm capacity source, all of which would be used to meet Belize's own base load.
Biomass	No	Yes	Biomass is a firm capacity source, all of which would be used to meet Belize's own base load.
Small Hydro (1–5MW)	No	Yes	Small hydro is a firm capacity source, all of which would be used to meet Belize's own base load.
Large Hydro (5–25MW)	No	Yes	Large hydro is a firm capacity source, all of which would be used to meet Belize's own base load.

All of the RE resources described above are based on a preliminary technical and economic feasibility assessment from our analysis. For the firm capacity sources, such as wind with pumped hydro, landfill gas, biomass, and small and large hydro, all the viable sites were assumed to supply Belize's own demand. Therefore, we cannot reasonably expect additional export capacity from these sources, unless they are built quickly before demand grows.

4.4.2 Screening for export markets

Solar PV in Belize is not anticipated to be a competitive generation source for export to neighboring electricity markets. This is based on comparing Belize solar PV prices to the wholesale electricity costs in the CFE and SIEPAC electricity markets. In our analysis, we only consider solar PV because it is the only RE technology whose generation would likely be available for export under the NSES scenario.

It would not be cost competitive to sell generation from solar PV into SIEPAC or CFE. In Table 4.6, we show the wholesale prices that generation from Belize would have to match by generating from solar PV (using the low-cost solar scenario).

Table 4.6: Export Market Screening for Solar PV from Belize

Electricity Market	Average Wholesale Electricity Price[1]	Generation Cost of Solar PV[2]
Belize	US$0.14/kWh	US$0.17–0.18/kWh
SIEPAC (via Guatemala)	US$0.15/kWh	US$0.17–0.18/kWh or lower
CFE (Mexico)	US$0.10/kWh	US$0.17–0.18/kWh or lower

Sources: [1] BEL System Dispatch Data, 2012 (Belize); Inter-American Development Bank, 2013 (SIEPAC); Comisión Federal de Electricidad, 2013 (Mexico)

[2] Castalia estimate based on low-cost PV scenario

CFE intends to rapidly increase wind production in the next two years, installing as much as 3GW of wind by 2015. Power purchase agreements for this generation are being signed for approximately US$0.06–0.07/kWh.[16] These transactions will further suppress CFE wholesale prices, making export of solar PV generation to Mexico even less competitive (especially for intermittent generation).

Mexico and most SIEPAC countries have locations with better solar resources than Belize. It would be cheaper for these countries to self-produce or sell into the SIEPAC market than it would be for Belize to supply them with solar PV.

4.4.3 Facilitating exports to neighboring markets

In order to be able to export electricity (whether from solar PV or other sources), the Government of Belize would need to coordinate with BEL and its neighbors on five critical steps:

- **Procure additional RE capacity** to meet domestic load over the duration of the NSES scenario
- **Conduct grid impact studies** of planned RE generation facilities. The studies would identify upgrades to BEL transmission and distribution facilities that would be necessary to export to the points of interconnection.

[16] McGovern, Michael. 2013. "Mexico – Top two slot confirmed as capacity more than doubles." *Wind Power Monthly.* http://www.windpowermonthly.com/article/1172001/mexico---top-two-slot-confirmed-capacity-doubles (accessed February 20, 2014).

- **Execute the necessary agreements with CFE** to strengthen the existing interconnection with Mexico
- **Execute the necessary agreements with the Government of Guatemala** to build an interconnection across Belize's southern border. In January 2014, the Governments of Belize and Guatemala signed a resolution before the Organization of American States to pursue such an agreement by the end of the year
- **Execute the necessary agreements with SIEPAC** to fully integrate Belize into the regional market.

4.5 Off-grid RE

Many Belizeans live off-grid, and some businesses operate in off-grid areas. Often, it is cheaper for these households and businesses to self-supply electricity from renewable energy, rather than using diesel generation or connecting to the grid.

According to the 2010 census, nearly 10 percent of Belizeans do not use electric lights in their homes, indicating that many areas need to be connected to the grid and may not be able to afford diesel generators. The cost of extending grid electricity is site specific, but for very remote areas, installing renewable generation will be cheaper than extending the distribution system. These opportunities have to be evaluated on a case by case basis, but in some instances, building RE systems may be more economical.

Our analysis shows that distributed scale generation from wind, solar, and hydro can be competitive, or save money compared to diesel generation. This means that communities currently using diesel generators would benefit from switching to renewable energy. The commercial sector could save money by self-generating with renewable energy; for example, off-grid hotels could use solar PV to reduce diesel consumption (and in fact some already do, such as the Hatchet Caye Resort). A comparison of diesel and RE generation costs is shown in Figure 4.6.

Figure 4.6: Levelized Cost of Off-grid Electricity

Technology	Installed capacity (plant size)	Unit Capital Cost	O&M costs per year	Vari. O&M (Incl. Fuel)	Lifetime	Capacity Factor	Output per kW capacity per year	Total system cost	Annualized capital cost	Annual O&M costs	Annual system output	Capital cost recovery factor	O&M cost per kWh	LRMC	LRMC
	kW	US$/kW	US$/kW/yr	US$/MWh	Years	%	kWh/kW/yr	US$	US$/yr	US$/yr	kWh/yr	US$/kWh	US$/kWh	US$/kWh	BZ$
2 kW Off-Grid PV (high estimate)	1.92	$ 9,897	$ 30	$ -	20	16%	1,384	$ 19,002	$ 1,657	$ 58	2,657	$ 0.62	$ 0.02	$ 0.65	$ 1.30
2 kW Off-Grid PV Belize (low estimate)	1.92	$ 6,928	$ 30	$ -	20	16%	1,384	$ 13,302	$ 1,160	$ 58	2,657	$ 0.44	$ 0.02	$ 0.46	$ 0.93
2 kW Diesel Generator	2	$ 510	$ -	$ 449.60	15	95%	8,322	$ 1,020	$ 105	$ 7,483	16,644	$ 0.01	$ 0.45	$ 0.46	$ 0.92
25 kW Wind Turbine	25	$ 6,000	$ 44	$ 0.02	20	22%	1,910	$ 150,000	$ 13,078	$ 1,101	47,742	$ 0.27	$ 0.02	$ 0.30	$ 0.60
2 kW Hydro	2	$ 4,700	$ 130	$ -	20	50%	4,380	$ 9,400	$ 820	$ 260	8,760	$ 0.09	$ 0.03	$ 0.12	$ 0.25

5 Barriers to Sustainable Energy

The unrealized sustainable energy potential presented in Section 2 consists of energy efficiency (EE) and renewable energy (RE) projects that are economically and commercially viable—projects that would save money for the country, and make money for those who implement them. That so many good opportunities would be unrealized suggests that they are being blocked by barriers of various kinds, which this section focuses on:

- Section 5.1 analyzes the barriers that prevent consumers from using EE measures
- Section 5.2 discusses barriers to distributed RE generation
- Section 5.3 examines barriers to utility scale RE projects.

5.1 Barriers to Energy Efficiency

Despite the potential to reduce consumers' energy costs with EE measures, uptake of EE remains low in Belize. The audit process conducted under this assignment suggests that this is the case for all classes of consumers; the reasons for that are barriers of different types.

A useful way to discuss different types of barriers to EE can be to consider the steps faced by someone who would want to install an efficient appliance or retrofit a building. These steps can be summarized by questions that a hypothetical consumer might ask in the process of implementing an EE project, as presented in Figure 5.1 below. Barrier types are indicated in parenthesis in the figure: agency, information, regulatory, market, finance, and skills.

Figure 5.1: Barriers by Step of Implementing an EE Project

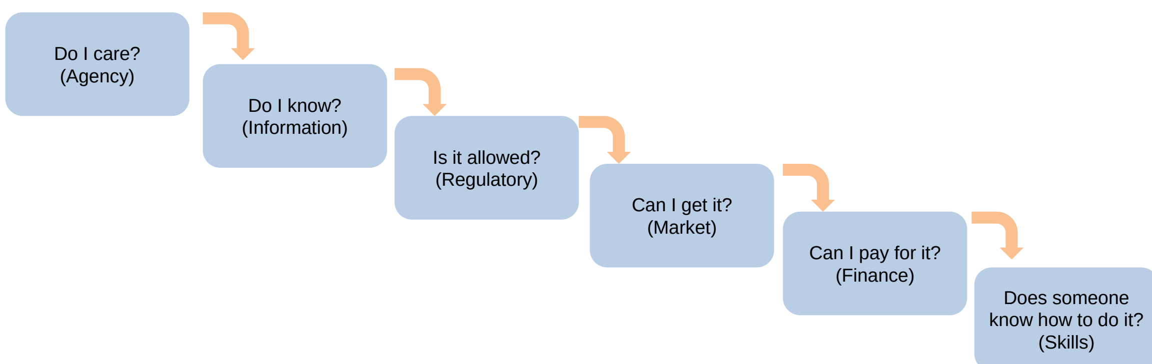

Table 5.1 summarizes the specific barrier types presented in the figure above.

Table 5.1: Types of Barriers to EE

Type of Barrier	Barriers
Agency	▪ Operating decisions (doing something that consumes energy) are split from investment decisions (what equipment to buy and install): – Private sector: developers and landlords have no incentive to invest in EE and prefer lower-cost, less-efficient equipment; those buying or renting are stuck with using that equipment, and also may have no incentive to invest in EE – Public sector: procurement officials are not incentivized to invest in EE; Government ends up paying more than it should for energy ▪ BEL's tariff structure makes it easier (in some cases) to pass the cost of inefficiency on to consumers, rather than investing in efficiency measures.
Information	▪ Energy consumers don't know about cost and performance of EE measures ▪ Energy consumers mistrust EE technologies that are new ▪ Service/equipment providers and financiers are unfamiliar with EE opportunities—and so are unable to adequately serve the market ▪ Consumers do not know good vs. poor service providers.
Regulatory	BEL's tariff structure, as it is, is not an incentive for it to support EE for its customers or itself, which could limit Belize's ability to achieve its full EE potential
Market	▪ EE equipment may be hard to find (especially out of Belize City) ▪ EE equipment may be priced too high.
Financial	▪ Upfront cost of EE measures is high for consumers ▪ Financing institutions may not provide lending on appropriate terms for EE ▪ Non-creditworthy customers cannot finance EE, leading to sub-optimal outcome from a social welfare perspective.
Skills	Service providers (electricians, engineers, building managers, and so on), financiers, and public entities do not have the skills to take advantage of EE; public entities may lack the skills to implement and monitor regulations related to EE

Each of the barriers in Table 5.1 is presented in further detail below.

5.1.1 Agency problems

Viable EE projects may not happen when agents who should make the decision to invest in them are not the same people who would use them. This mismatch between capital and operating expenditure decisions is known as an 'agency problem,' and its effect is to neutralize incentives for EE. For example, a landlord decides what appliances to install in an apartment he or she rents out to others. For the landlord, the answer to the question 'do I care?' is 'no,' because he or she is not the one paying the monthly electricity bill.

Private sector: developers and landlords go for lower-cost, less-efficient options

Developers and landlords determine in large part the energy consumption profile of those who will buy or rent their buildings. For example, a developer will often be the one who chooses what type of windows, insulation, and appliances to install. A landlord will choose many of the largest appliances to include in a building he or she lets. They may see no incentive to pay more upfront to make it possible to pay less afterwards, because they would not be the ones who pay afterwards. In fact, they may have a perverse incentive to go for cheaper equipment that minimizes their costs and increases their profit—at the expense of others.

On the other side of these transactions, consumers facing the 'operating decision' are stuck with someone else's decision, and lose. Those who rent[17] have limited scope to invest in EE, because they may be unable to recover an investment in a property they do not own, especially if they occupy it for a short period. Those who buy will want to amortize the equipment they got as part of their investment in the overall building before they replace it—if they ever do. Since most people in Belize own their home, the latter kind of inefficiency will be more frequent in households; the former kind, in businesses.

Public sector: procurement officials lack incentives to invest in EE

Government procurement agents may not see the incentive of investing in more capital-intensive EE equipment because they would not pay the energy bill out of their own pocket, or even out of the budget allocated to any specific department. Bills are mostly paid directly by the Ministry of Finance; and it may be easier to expect the Ministry of Finance to pay for high electricity bills on an ongoing basis, than to pay for a more costly measure. This leads to energy-consuming equipment being chosen based on lower upfront cost rather than long term operating cost, increasing Government expenditure.

In fact, often those in charge of procurement (in the public and private sector alike) also face budget limitations that further orient them towards less efficient options; or just do not appreciate how spending more upfront would end up making them spend less overall. High upfront costs and financing constraints are dealt with under the 'financial barriers' section 5.1.5 below; information barriers are discussed in section 5.1.2.

It is easier for BEL to pass some inefficient costs to consumers than to invest in EE in its own operations

BEL does not face strong incentives to invest in efficiency measures to reduce technical and commercial (non-technical) losses. There are two main reasons for this:

- The regulated performance targets for technical and commercial losses do not impose penalties for failing to meet the target
- The design of the technical and commercial losses performance targets results in targets that are far lower than regional norms, meaning that attaining them would likely cost BEL more than the incentive payment it would receive for meeting them.

[17] According to the 2010 Census, 64 percent of Belizeans own their homes and 36 percent rent. Some renters may rent 'all inclusive' units that include utility costs. In these cases the landlord does have an incentive to invest in efficient equipment, so this barrier does not apply.

Under the Rate Setting Methodology (RSM) adopted in 2008, BEL faces performance targets for technical and commercial losses. If it succeeds in meeting either (or both) of the two performance targets, BEL is entitled to keep 50 percent of the cost of power savings realized by meeting each respective target. However, BEL does not face any penalty for failing to meet either of the targets.

This lack of a penalty is particularly important, given the design of the performance targets set out in the RSM. The RSM sets a kWh allowance for technical and commercial losses, respectively. Each allowance changes over the course of the regulatory period (full tariff period, FTP). The allowance is based on an improvement factor set at the beginning of the FTP. Since 2005, the improvement factors have not changed, nor have the base-year kWh allowances for technical and commercial losses.[18] At the same time, the demand forecast used in setting the revenue requirement (tariff basket revenue, TBR) has grown. The end result is that by the end of the current FTP in 2016, in order to earn incentive payments, BEL will need to achieve 6.1 percent technical losses and 0.9 percent commercial losses. This represents a target that is likely unachievable, given that the average for total system losses among Caribbean electric utilities is 10.7 percent. This figure also skews low for a system like BEL's since it includes utilities with service territories much smaller than BEL's territory.[19]

5.1.2 Information barriers

'Information barriers' exist when those who may be expected to implement profitable EE opportunities do not know about them: what they are, how they work, how much they cost, and how much they save. Our audit experience suggests that Belizeans are aware of many EE opportunities—but not all of them. Also, as technologies evolve, even known EE measures change, in terms of both costs and benefits.

Consumers don't know about costs and performance of EE measures

Consumers may not have all or some information needed to evaluate the EE measures that they could be using to save money. A consumer may not know that a certain technology exists; or, if they do, may not know how much money it saves and how much it costs. Even if consumers try to find information about a technology, they may not be able to find reliable information; the labeling on the product itself may not provide the information the consumer requires. For new technologies, there can be a 'chicken-and-egg' problem with information. People may not be aware of a technology until it is widespread, and lack of awareness can prevent a technology becoming widespread.

Energy consumers mistrust new technologies

Consumers in any country tend to take a cautious view of new technologies, and our work suggests that is the case in Belize as well. Even if the prices of an efficient technology and a conventional technology are the same, some consumers will prefer to buy the technology

[18] Since the 2005 Full Tariff Review Proceeding, the improvement factors have remained fixed at -3.5 percent for technical losses and 0 percent for commercial losses. The base-year kWh allowance for technical losses remains at 42,667,521kWh, while the allowance for commercial losses remains at 5,215,339kWh.

[19] CARILEC. September 2013. "2012 Benchmark Study of Caribbean Utilities."

they are familiar with, rather than risk the chance that the new technology does not perform as they expect it to.

Service/equipment providers and financiers are unfamiliar with EE opportunities

Selling EE products and services represents a new opportunity for Belizean businesses, but many potential service and equipment providers are unaware of the opportunity. For example, there may be EE products that would work well in Belize, but the owner of a hardware store may not know to import them. Likewise, there are engineering firms who could develop a business line doing energy audits, but do not do so, because they are unaware of the opportunity that EE represents. Banks could also make money by lending for EE projects, but are prevented from doing so by lack of information about the business opportunity. This barrier is related to another: lack of skills and expertise, which we discuss in section 5.1.6 below.

Consumers do not know good vs. poor service providers

It may be difficult for consumers to tell good energy efficiency services from poor ones. This is due to an information asymmetry between those who supply EE services (just like other services) and those who demand them: the former know far more about their skills and expertise than the latter.

This information asymmetry acts as a market barrier to uptake of EE technologies. Consumers may find the risk of getting of getting bad service too great to justify investing.

5.1.3 Regulatory barriers

Regulatory barriers occur when money-saving EE measures are prevented from being realized by Government regulations.

No EE measure is forbidden by regulation in Belize. However, the design of the revenue decoupling mechanism in the RSM provides weak incentives for BEL to help its customers be more energy efficient—even when the decoupling mechanism is intended to do the very opposite.[20] For example, the Cost of Power Rate Stabilization Account is an accrual account designed to serve as a means of smoothing volatility in wholesale power prices to avoid rate shock. However, it has historically been used as a long-term deferral account, which continues to grow as actual power prices increase relative to the reference cost of power embedded in tariffs. The end result is that the revenue decoupling mechanism does not provide the utility a fair opportunity to earn a reasonable return—and so, BEL faces an incentive to boost energy sales in order to maximize revenue and its return.

All of this means that the potentially largest energy service company in Belize faces weak incentives to leverage its customer base, trained workforce, or financing capabilities to invest in EE that could save money for its customers.

5.1.4 Market barriers

Other barriers prevent the market for EE technologies and services from 'clearing.' That is, they prevent supply from meeting demand at what should be the optimal equilibrium point.

[20] These weak incentives arise primarily through the design and implementation of the Cost of Power Rate Stabilization Account, and the ability of the PUC to retroactively set allowed cost components for a given year in the Full Tariff Period.

The two market barriers observed in Belize are that equipment is not always available, and is not priced competitively; therefore, consumers cannot get it. Of course, shortage of supply and excessive price are more than just closely related—they happen together.

EE equipment and services may not be readily available

EE equipment and services can be difficult to find in Belize. Few firms can perform energy audits; and not all EE technologies are readily available (though many are, at least in Belize City). Outside of larger towns, these services and technologies are even more difficult to find. The availability of EE equipment and services can be a 'chicken-and-egg' problem: if customers look for the technology and don't find it, they may stop looking. This causes suppliers to perceive lack of interest in the technology or service, and not supply it. All of this prevents good EE projects from being developed.

EE equipment may be priced too high

Linked to the problem of availability is the pricing of equipment and services. If equipment is imported in small amounts, then it will not benefit from bulk order pricing. Similarly, if the market for EE services is small, there will be little scope for economies of scale in service provision and competition, therefore increasing prices. Higher prices prevent consumers from developing money-saving projects, and make financial barriers (discussed in the next section) worse.

5.1.5 Financial barriers

Since the upfront costs of certain EE measures (or of several packaged together) can be high, many consumers cannot pay for them unless they get financing to cover some part of the investment cost. However, often consumers are unable to get financing: either because of malfunctioning information flows within financing markets; or because of their consumers' creditworthiness.

We found no evidence suggesting that financial institutions in Belize offer worse terms for EE investments than for any other investment, specifically because they are EE projects. However, it is possible that banks' lack of familiarity with EE technologies (as discussed above) may lead them to offer terms that do not correctly reflect risks and returns of those investments: short loan tenor, high rates, and high request for collateral. Of the institutions contacted (including Atlantic Bank, Belize Bank, Heritage Bank, and Scotiabank), only the Development Finance Corporation (DFC) of Belize has set up a dedicated EE lending line, with preferential terms that are somewhat better than its other products (rates as low as 8.5 percent, tenor up to 15 years, and grace period up to two years).[21] The problem the DFC says it faces is a lack of skills to evaluate opportunities and extend the line to borrowers.

Even assuming that financing institutions did provide good loans for EE projects, poorly qualified borrowers could not take advantage of them. This would not be a malfunctioning of financing markets—in fact, it would show how they work well. However, it does lead to a sub-optimal outcome from a social welfare point of view. Consumer spending is funneled into inefficient consumption: consumers could get the same welfare from their energy use but paying less for it, and the country is worse off.

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[21] Development Finance Corporation of Belize. *Eco-friendly loans*. http://dfcbelize.org/eco-friendly-loans/; *Industry loans*. http://dfcbelize.org/industry-loans/ (accessed 20 November 2013).

5.1.6 Skills and expertise barriers

Even assuming that a consumer cares about EE, knows about it, can implement it, can find it on the market at reasonable price, and can pay for it, he or she may end up not implementing it. Opportunities to save money through EE may not be realized due to the lack of specific skills to execute the EE projects. Lack of skills impacts different sectors of the economy in different ways:

- **Few or no service providers** in Belize can conduct energy audits to determine the EE potential of specific buildings; this makes it more difficult to provide retrofit services, for which there is also a skills shortage
- **Most financiers** cannot evaluate EE investments accurately, as noted above
- **Public entities** do not have sufficient staff with energy management expertise to implement EE programs in public facilities; they may also not have the expertise to negotiate service contracts with energy services companies (ESCOs). Public entities responsible for implementing and monitoring policies, regulations, and programs for EE may lack the skills to effectively do their jobs.

5.2 Barriers to Distributed Renewable Energy

One can talk of 'barriers' for something that blocks **viable** projects, and distributed RE generation is only marginally viable in Belize at current costs and performance. Only getting the very best deals would make solar PV competitive with the tariff for grid-connected consumers, as noted in section 4.2. Off-grid consumers will find it more attractive (see section 4.4). However, there remains just one major load center not connected to the National Transmission Grid System (Caye Caulker)—and there are plans to interconnect it in the next 15 years.

However, it is possible that barriers to distributed generation will become more important in the future as their costs fall and/or their performance improves, making them a greater option for customers to save money.

Generally, most barriers that apply to EE (as presented above in section 5.1) would also apply to distributed RE generation: agency problems, limited information, market malfunctioning, financing constraints, and lack of skills. For example, just as there are few technicians trained in conducting energy audits, there are likely too few technicians with skills installing and servicing distributed RE systems. The technicians there may be geographically far away from the system, making it more costly for them to service the system. In addition to the barriers common to both EE and distributed RE, there are two specific regulatory barriers to distributed RE:

- From the customer perspective, owners of distributed generation systems cannot sell their excess generation to the grid
- From the utility's perspective, Belize's tariff structure would make distributed generation hurt BEL's financial viability.

A third barrier might also arise as a distributed RE generation scheme is implemented and puts strain on BEL's human resources to inspect applicants' systems.

Any strategy to integrate distributed generation into the national grid must carefully mitigate the risk that (i) BEL's financial viability is threatened, and (ii) solar PV users increase the cost of service for those customers without solar PV systems.

5.2.1 Owners of distributed RE systems cannot sell excess generation

There is no arrangement in place for customers to sell back to the grid the generation they do not use. This means that system owners cannot get the full value of their system unless they consume 100 percent of the electricity they generate. Without interconnection, the surplus energy that a system generates (or could generate) goes to waste, and the system owner does not realize the full return on their investment. The Public Utilities Commission (PUC) and the MESTPU are developing an interconnection framework to overcome this barrier, which should therefore be solved soon.

5.2.2 The tariff structure would make distributed generation hurt BEL's financial viability

The current tariff structure depends on the number of kWh sold to cover not only generation costs, but also transmission and distribution. Residential and small commercial customers are only subject to a per-kilowatt hour energy charge that bundles fixed and variable costs of service. Only larger commercial customers and industrial customers are subject to a service charge, and only industrial customers are subject to a demand charge.[22]

This means that most of BEL's customers who would generate with their own solar PV system would continue to enjoy BEL's services of backup and standby generation, and interconnection with the grid. However, they would not pay for all or part of those services, because the way they pay for them is only or mostly by consuming kilowatt hours—and they would consume less (or none) of those thanks to self-generation.

In turn, this would mean that BEL would still face capital costs to provide backup generation, transmission, and distribution services—but its ability to recover those costs (and earn a return on them) would be limited.

5.2.3 Inspection of systems might put strain on BEL

Systems eligible under any scheme will require inspection to ensure compliance with the interconnection agreement. When distributed generation schemes are first implemented, human and technical resources of a utility can become subject to an excess of demand for inspections. This is likely to happen if uptake is much more and faster than expected.

5.3 Barriers to Utility Scale Renewable Energy Development

With over 50 percent of total generation coming from renewable sources, Belize is a leader in utility scale RE development—as also shown in the 2014 ranking done for the Caribbean Renewable Energy Forum.[23]

Despite Belize's extensive and successful experience in developing utility scale RE, there remain unrealized opportunities to decrease the cost of service while maintaining its quality

[22] BEL Rate Schedule. http://www.bel.com.bz/Rate_Schedule.aspx (accessed 20 November 2013).

[23] CREF-Castalia Renewable Energy Island Index, October 2014. http://www.caribbeanenergyforum.com/themes/cref/pdf/cref-castalia-index-2013.pdf (accessed 20 November 2013)

and reliability, due to some residual barriers illustrated in Figure 5.2 and summarized in Table 5.2 below. The remainder of this section discusses those barriers in detail.

Figure 5.2: Barriers by Step of Implementing Utility Scale RE Projects

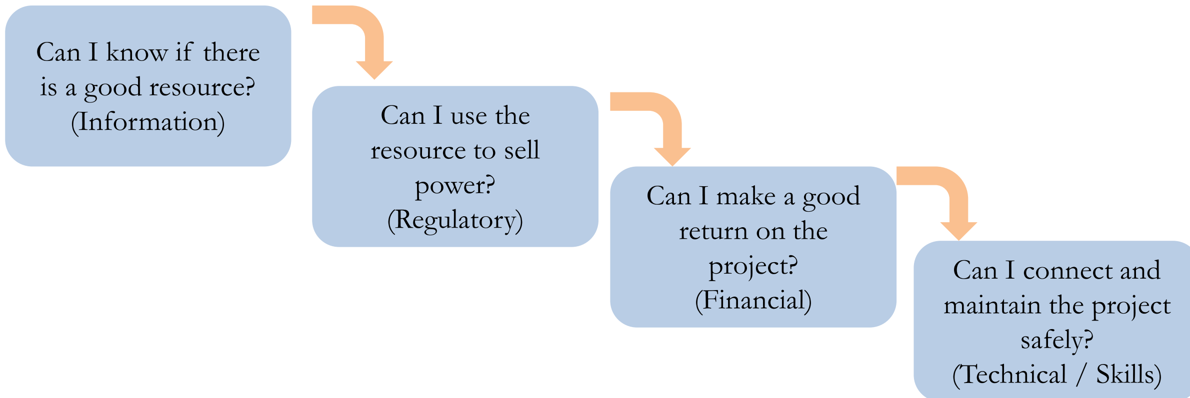

Table 5.2: Types of Barriers to Utility Scale RE

Barrier Category	Barrier
Information	Lack of investment-grade resource assessments
Regulatory	Ability to use a renewable resource: unclear situation for hydro sites in the Upper Macal River
	Ability to access and develop a site in a way that preserves the environment: unclear framework for unprotected and protected areas—although Government policy set to address it
	Ability to sell electricity commercially: (1) limited licensing regime, and (2) a few weaknesses in RE tendering
Financial	Possible limited investor interest, leading to higher costs for large RE in Belize
Technical / Skills	Limited familiarity with grid interconnection of intermittent RE; limited experience operating certain classes of RE assets

5.3.1 Information barriers

Investing in renewable generation assets requires investment-grade information on the quality of the underlying resource. Better resource assessments for biomass, hydro, and waste would help spur development. Table 5.3 summarizes the status of RE resource assessments in Belize, and areas where more work is required.

Table 5.3: Status of Renewable Resource Assessments

Resource	Existing Information Quality	What's Needed
Biomass	Poor	Study on agro-wastes, logging residues, and energy crops
Hydro	Fair	Additional hydro monitoring stations
Solar PV	Good	Nothing
Waste	Fair	Power sector focused assessment
Wind	Good	Nothing

- **Biomass**—there are no studies on the use for electricity generation of agricultural residues (other than bagasse) or logging residues. The limited scale of individual biomass sources (other than bagasse) is likely to contribute to this problem. This limits the ability to assess opportunities for biomass-based generation in the country. Some studies on energy crops have been completed in Belize; further studies on different energy crops would allow comparison among the various options
- **Hydro**—there are many hydrological measuring stations in Belize. However, a study from 2006 (Poyry) finds that many of the historic readings are of poor quality, and should be updated and improved. Belize's experience in utility-scale hydro is great—and better information on the sites that remain could help bring to the market an installed capacity of about half of the system's current peak demand. Fortunately, new monitoring equipment has been installed at some sites already
- **Solar PV**—the assessment by the United States' National Renewable Energy Laboratory (NREL) of Belize's solar resource, and data on the performance of the University of Belize's PV system provide a good guide to solar potential
- **Waste**—a 2011 report on waste generation in the Western Corridor provides general information on waste resources available in that region, but it does not assess the resources specifically for power generation. The need to aggregate information from smaller-scale sites may contribute to this situation
- **Wind**—we have heard that site-specific studies have been conducted by Belize Wind Energy Limited; the results are (understandably) confidential and we have not seen them. The fact that such studies have been done shows that investment-grade information for wind power development may be secured in Belize.

5.3.2 Legal and regulatory barriers

A developer of RE projects needs a country's legal and regulatory framework to ensure three basic things: the ability to use a RE resource, the ability to access and develop a site, and the ability to sell electricity commercially. Rules for these three things should balance the interest of developers with those of the country to ensure win-win outcomes from good projects.

As noted, Belize's successful experience with utility scale renewables shows that the country's 'enabling environment' has proven effective. The barriers described below address a few residual aspects that could be improved.

Ability to use a renewable resource: unclear situation for hydro sites in the Upper Macal River

It will be difficult to get key hydro sites privately financed until the situation with BECOL is solved. This situation focuses on two matters, explained below: the need for BECOL to approve developments in the Upper Macal River; and the fact that BECOL is operating without a license.

The Third Master Agreement between the Government, BEL, and BECOL calls for BECOL's approval for any development (consumptive or non-consumptive) on the upper Macal River, defined as the portion of that river above and including the Mollejon site, and the Macal's River's tributaries. This includes the following sites included in the NSES scenario shown in Section 2: Vaca II, Mopan River Cascade (Mopan is a tributary of the Macal), Chalillo 3, and the 8.4MW site downstream of Vaca Falls. According to the PUC's interpretation of the Agreement,[24] the reason for this required approval is to protect BECOL's investment—as developments on the upper Macal River may affect the output of BECOL's plants of Mollejon and Chalillo. The PUC does not interpret such provision as a right of first refusal. However, the situation remains in dispute.

BECOL is operating without a license. Originally, BEL's license and the Third Master Agreement allowed BECOL to generate through its association with BEL. However, BECOL is no longer an 'affiliate' of BEL since they do not have the same ownership. Therefore, it may no longer use BEL's license to generate. According to the PUC, BECOL has claimed that their agreements with the Government and BEL allow them to operate without a license. The PUC does not agree with this position, and considers that BECOL should have obtained a license since the very beginning of its operation. However, the PUC has not begun any progress to enforce its position from a legal perspective.

Ability to access and develop a site: unclear framework for unprotected and protected areas—although Government policy set to address it

Renewable energy development must be carried out in a responsible manner that carefully weighs damage to Belize's significant environmental resources. The process required to obtain an environmental permit to build a power plant is unclear for both unprotected and protected lands. This creates an additional barrier to developing a RE project.

The lack of legal clarity around the use of forest reserves, conservation areas, national reserves, and national parks for power generation may create a barrier to RE development; a developer may worry that an inadequate environmental review process could lead to social opposition to his project if the environmental review did not adequately protect a sensitive area. Some of Belize's RE resources lie within protected areas, for example:

[24] Third Master Agreement, §3.3: *The Government hereby covenants not to grant, or permit the granting of, any consumptive, non-consumptive or other rights on the Macal River or its tributaries, or to take any action, or allow any third party to take any action if the effect of such grant or action would be to impede, affect or direct in any manner the amount, quality, or flow of water in the Upper Macal Rjver, unless the Government obtains the Producer's prior written consent.*

- The Cockscomb Basin Forest Reserve includes two major watersheds (and therefore potential hydro sites): the South Stann Creek, and the Swasey Branch of the Monkey River; and also includes a small portion of Sittee River via Mitchell Creek drain the Basin. The NSES scenario estimates an overall potential for small hydro which includes these sites as well as others
- Baldy Beacon (a wind site) is within the Mountain Pine Ridge Forest Reserve. This site is also included in the NSES scenario.

Of course, some sites should not be developed due to the unique nature of the area in which they are located. Others, however, might be safely developed with minimal damage to the local environment.

However, project developers may be deterred by the lack of legislation specifying which protected areas may be considered for power generation and under what conditions. The following laws do not address power generation from RE in protected areas:

- The Forests Act, Chapter 213
- The Environmental Protection Act, Revised Edition 2003, Chapter 328
- The National Parks System Act, Chapter 215
- Ancient Monuments and Antiquities Act, Chapter 330
- The Fisheries Act, Chapter 210.

The Environmental Protection Act does specify that 'any large installation for the production of electricity, steam or hot water' requires a full environmental impact assessment, but this applies to projects inside and outside of protected areas. There is not a specific environmental permitting process for renewable energy or other types of electricity generation facilities.

Policy issued by the Government, however, seems to recognize the need to reconcile protection of certain areas with the opportunity to exploit the country's RE potential:

- The National Protected Areas Policy (2005) calls for the Government to 'enhance the quality of renewable resources, and strive for the optimum use of non-renewable resources'[25]
- The National Energy Policy (2011) calls for the Government to

  …strengthen the existing Land Use Policy, based on the recommendations of the Natural Resource Use Planning Study, detailing the boundaries of portions of land and marine areas that are to be reserved for a particular purpose and the purpose of its future use. Any proposal or request to de-reserve a portion of land or that would use a portion of land set aside for a particular purpose under the Land Use Policy should require the authorization of the Ministry of Natural Resources acting on the advice of the [National Energy and Electricity Planning Institute] NEEPI
- The National Energy Policy also calls for the NEEPI to be responsible for:

[25] Task Force on Belize's Protected Areas Policy and Systems Plan (November 2005). *The Belize National Protected Areas System Plan*. Page 6.

> *…demarcating and designating renewable energy zones throughout Belize….These renewable energy zones should be afforded similar protections, under law, to those which are currently given to nature reserves. Licenses should only be approved for renewable energy projects which are to be developed within the renewable energy zones.*[26]

Ability to sell electricity commercially (1): limited licensing regime

Belize does have licensing provisions for the electricity sector enacted in the Law, but not a full licensing regime. The Electricity Act[27] does the following:

- Establishes the statutory power of the PUC to grant licenses for generation, transmission, distribution, and commercialization
- Requires that an application for a license or extension must be made in the prescribed manner
- States that only generation above 75kW of capacity needs a license
- Requires the PUC to state the reasons why it proposes to grant a license
- Includes general provisions about terms and conditions.

However, there are no indications regarding the criteria, standard conditions, or terms for granting a license—nor does the Act specify the items required as part of the application. The granting of a license is likely to seem like a case-by-case matter subject to unclear criteria, requirements, and timeline to potential developers. Investors (especially the best ones) may be deterred by perceptions of high uncertainty and discretion.

Further, it is very appropriate for the Act to include a 'floor value' below which no licenses are required for generation—but 75kW might turn out to be too low if and when distributed RE generation picks up in Belize. This floor value varies throughout the Caribbean, Central America, and the United States, depending on the size of the RE market, and the level of local experience with interconnecting intermittent distributed generation.[28]

Ability to sell electricity commercially (2): a few weaknesses in RE tendering

The Ministry of Energy, Science, Technology, and Public Utilities (MESTPU) and the PUC issued a Request for Proposals for electricity generation on 7 October 2013 (RFPEG 2013). As of 26 November 2013,[29] almost 50 prospective bidders purchased the full RFP document. Technologies of interest include solar, wind, biomass, waste to energy, hydro, as well as thermal—and hybrid solutions; some bidders did not indicate any particular technologies, which was not required at the stage of purchasing the RFP document. Notably, and reflecting previous observations, BECOL and Fortis Belize Limited declined to participate in the tender.

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[26] Government of Belize (2011). *National Energy Policy Framework*. Pages 16 and 19.

[27] Chapter 221, Revised Edition 2000, Part III, Sections 14–29

[28] For comparison, some regional floors are as follows: Dominica (15kW), Barbados (no floor, as long as generator's primary business is not the sale of energy), Jamaica (100kW), México (500kW), and up to 20MW in the United States (varies by state).

[29] Communication by the PUC, 26 November 2013.

Project proposals were compared through energy and capacity dispatch simulations over the 2014-2030 period to identify the ones most appropriate for Belize. Following the evaluation and selection process, seven projects were recommended for immediate negotiations with BEL and subsequent execution for a total of 78.2MW. Of these, six (for a combined capacity of about 71MW) were renewable energy projects including biomass cogeneration, hydro, and solar. Another hydro project was recommended as back-up.[30]

Investor interest in the RFPEG 2013 proved good, with the notable exception of BECOL for key hydro sites. There are also successful precedents of two prior RFP processes, both of which were for all technologies, including RE:

- 2003 RFP: Hydro-Maya turned out to be the lowest cost option. BELCOGEN was also granted a license
- 2007 RFP: thermal options proposed by BAL and Belize Natural Energy (BNE) were the lowest cost options. The Vaca and BAL plants were constructed, but with special preferences granted to hydro (50 year license, and waiver of requirement for firm capacity).

A few weaknesses in this overall successful experience may be the following, all related to some degree of uncertainty faced by investors:

- **There was no indication about most key terms of power purchase agreements (PPAs) to be signed**. The RFP document did include a section (section 5) about the contract basis, which listed the key terms. However, most of them were simply listed as items that shall be included in the PPA, with no reference to what the substance of those terms would actually be. For example, section 5 simply stated that 'The contract shall define the scope and causes of force majeure'—but how to define this, as other matters, is subject to many options. This limits to some extent investor certainty. RE tender processes (such as the one conducted in Jamaica recently) often provide as part of the RFP package a standard PPA—which may be negotiated, but which also provides greater certainty and speeds up the process of negotiation. (Two notable exceptions of appropriate terms actually explained in full in the RFP's section 5 are: the need to obtain BEL's approval for planned and maintenance outages; and the requirement to respect the Grid Code)
- **The stages and rules of the qualification and evaluation process were not fully clear**. Qualification and evaluation were mixed together: an overall scoring system assigns (1) up to 20 points to the 'technical, financial, and management component"; (2) up to 60 points to the 'price component'; and (3) up to 20 points to the 'socio-economic component'. Bids had to score at least 15 points on the first component—which became in effect a qualification stage. The criteria for assigning points under the third component ere not spelled out in detail, and likely to have to be subject to discretion. This might, to some extent, have limited bidders' perception of transparency of the process

[30] Public Utilities Commission (2015) RFPEG Belize 2013 – Final Report. 2nd Phase Evaluation and Selection. 6 March 2015. Accessed at http://www.puc.bz/images/Publications/aRFPEG2013-Final%20Report_PUC%20.pdf

- **There was uncertainty regarding licensing**. The RFP document only stated that successful bidders shall be required to obtain a license, which shall be issued in compliance with the Electricity Act, sections 14–29. As noted above, the rules and processes based on which any license may be issued, and standard terms, are not known. This is likely to have added uncertainty and time to the process.

Among the rights reserved by the PUC, MESTPU, and BEL is the right to 'amend the parameters of the RFP process as may be warranted from time to time, including on the basis of comments, concerns, or recommendations received by participants.' As we discuss in Section 6, this may be a way to improve on some of the shortcomings listed above.

5.3.3 Financial barriers

The nationalization of BEL and the unresolved matter of BECOL's contract may have reduced lender and equity investor willingness to finance power projects in Belize. Regardless of the reasons for the nationalization, and regardless of the sector's tradition of IPP generated power, some investors may still be hesitant. Some lenders and investors, perhaps some of the best ones that can invest in other countries, may choose not to invest at all. Others may demand a higher return on capital to compensate for what they consider a higher risk environment. This effect can be observed in other countries that have nationalized companies; for example, equity investors will demand a return approximately 10 percentage points higher to investment in Argentina than to invest in the same project in Austria.[31] Fewer potential investors demanding a higher rate of return means higher project costs—potentially making good RE projects unviable.

5.3.4 Technical barriers

Lack of familiarity with the technical aspects of integrating intermittent sources of RE into the grid presents a barrier to their exploitation.

The current grid code is inadequate to integrate intermittent RE

Requirements for the integration of intermittent generation on the BEL grid do not exist. BEL's Transmission Grid Code has detailed requirements for connecting generation to the transmission system, but there are no performance requirements for intermittent (wind or solar) generation. Because intermittent generation performs differently from firm generation sources, connecting it without specific guidelines may lead to grid instability and poor performance. The key technical requirements for interconnecting[32] intermittent generation, with regard to impact on grid reliability, are: protection requirements, voltage and reactive power control capabilities, voltage and frequency ride through, power quality, and energization.

Power plants are not currently permitted to connect to Belize's distribution system (defined as lines below 69 kV). In many cases, sites with good renewable resources may be located

[31] Based on data from Aswath Damodaran. Accessed online at: http://pages.stern.nyu.edu/~adamodar/

[32] Manufacturers of wind generators or inverters provide the guaranteed performance of each unit. This includes reactive power capabilities, voltage and frequency ride through, short circuit contribution, power quality, and others. But, connection requirements for intermittent generation are normally defined at the point of interconnection (POI), rather than for each individual unit, since the units first feed into a low voltage (unusually 34.5 kV) collector system, which is connected to a substation with a step up transformer.

closer to distribution lines than to transmission lines. For projects below 20MW located close to both transmission and distribution lines, connection to the distribution system is likely be more economical than connecting to the transmission system.

BEL has limited experience managing intermittent RE

BEL's limited experience in managing intermittent RE generation may limit its interconnection to the grid—including to reach the potential of 20 percent of peak load as considered in the NSES scenario. In 2013, BEL only had 480kW of intermittent generation capacity connected to the grid (from the University of Belize solar PV plant).

Lack of local skills to operate renewable energy technologies

Belize's electricity workforce does not have experience operating certain types of technology; for example, utility scale wind or solar PV plants. This lack of skilled labor can make it more difficult to operate a power plant profitably; for example, costly foreign-labor may need to be brought in to fill certain roles.

6 Recommendations to Overcome the Barriers to Sustainable Energy

Targeted policy, regulatory, and financial interventions can overcome the barriers that prevent greater adoption of sustainable energy in Belize.

This section presents preliminary recommendations for:

- Overcoming barriers to EE (Section 6.1)
- Overcoming barriers to distributed RE (Section 6.2)
- Overcoming barriers to utility scale RE (Section 6.3).

Several of these recommendations are similar, or consistent with recommendations contained in the National Energy Policy (NEP) and the MESTPU Strategic Plan; for example, conducting investment-grade studies for further hydro sites. The Sustainable Energy Action Plan (a separate document that accompanies this report) explains how the actions below should be carried out, by whom, and when.

6.1 Overcoming Barriers to Energy Efficiency

Table 6.1 shows a summary of the barriers that prevent EE measures from being implemented (as presented in section 5.1), and proposed interventions to overcome those barriers.

Table 6.1: EE Barriers and Solutions

Type	Barriers	Recommendations
Agency	Private sector: developers and landlords have no incentive to invest in EE and prefer lower-cost, less-efficient equipment; those buying or renting are stuck with using that equipment, and also may have no incentive to invest in EE	Introduce a Building Code mandating EE
	Public sector: procurement officials are not incentivized to invest in EE; Government ends up paying more than it should for energy	Contract private sector firms to retrofit public building under contracts that align their success with energy savings; make Government departments directly responsible for energy bills
	BEL's does not have a strong incentive to control the costs it passes on to consumers	Implement regulation with stronger efficiency incentives for BEL
Information	Energy consumers don't know about cost and performance of EE measures	Implement public awareness initiatives; adopt a labeling system for EE products in coordination with other countries in the region; or develop national energy performance standards; consider requiring buildings to have energy management systems
	Energy consumers mistrust EE technologies that are new	Provide information about EE technologies; require retailers who participate in a

Type	Barriers	Recommendations
		financing facility to provide warranties
	Service/equipment providers and financiers are unfamiliar with EE opportunities—and so unable to adequately serve the market	Provide training (workshops, on-the-job training, embedded experts for 'pilot periods')
	Consumers do not know good vs. poor service providers	Adopt a certification system for EE services
Regulatory	BEL's tariff structure, as it is, is not an incentive for it to support EE for its customers or itself, which could limit Belize's ability to achieve its full EE potential	Improve decoupling of BEL revenues from sales of energy only, and allow it to better recover costs and earn a return on helping its customers implement EE
Market	EE equipment may be hard to find (especially out of Belize City), and may be priced to high	Implement consumer finance scheme with bulk purchases to increase volumes and reduce costs
Financial	Upfront cost of EE measures is high for consumers; financing institutions may not provide lending on appropriate terms for EE; non-creditworthy customers cannot finance EE, leading to sub-optimal outcome from a social welfare perspective	Provide concessional lending and other financial mechanisms for EE as part of a 'Sustainable Energy Fund' or similar instrument
Skills	Service providers, financiers, and public entities do not have the skills to take advantage of EE	Provide specialized training on required skills

Each of the specific interventions summarized in Table 6.1 is described in greater detail below. As noted above, most of these interventions would also be applicable to distributed RE systems, if and when their uptake increases in Belize. Further, there are cross-effects between different recommendations. Examples of EE interventions in other countries are included in Appendix A.

6.1.1 Agency interventions for EE

Interventions that address agency barriers would align the interests of the party who pays for investment at a facility and the person who pays the operating costs of a facility.

A **Building Code that mandates minimum standards for EE** would make it compulsory to invest in equipment and material that benefits those who pay the energy bills. This measure would benefit all new buildings, in the private and public sectors alike. It is also likely to help develop the market for EE equipment, positively interacting with recommendations for overcoming market barriers. An existing code that is appropriate for Belize may be adopted with some adaptation, without the need to develop a full new one. For example, there may be appropriate building codes in nearby countries that could be adapted to Belize's context.

Hiring private contractors to retrofit public buildings would overcome the agency problem by entrusting implementation to specialized energy services companies (ESCOs) that make a profit out of implementing EE. Many or all public buildings could be bundled into one contract to make it more attractive to qualified service providers, given the relatively limited scale of investment that would be required (compared to the size of the potential ESCO investments in other markets). Contracts used to hire such companies should be designed to align the contractor's interest with the Government's interest in saving energy.

A simplified version of performance contracting is likely to be a good option for Belize. Full ESCO contracts only work in larger and more advanced markets such as the US or Canada where this business model is more mature. In these markets, ESCOs finance their interventions completely and are repaid out of the energy savings their interventions generate. In Belize, as in other countries in the region, an option where ESCOs can recover their costs through a normal payment, and get a bonus for performance above pre-determined levels, will be more attractive. The capital costs of the project could be paid by the owner as part of the overall price paid to the ESCO.[33] Donor or climate change funds may also be available to pay the initial capital cost of the retrofits, making it more affordable for the Government.

This measure should also be combined with IDB procurement rules, processes, and contracts. Doing so would provide more certainty to investors, while also protecting the interests of the Government with proven procurement tools instead of being subject to ESCOs' contracts.

Making Government departments directly responsible for their energy bills may help align interests of those who work in those departments and the Ministry of Finance. A lighter version of this measure that could be considered is prizes for the most efficient departments on a first-come, first-served basis.

Finally, there are three possible **regulatory solutions that could better incentivize BEL to operate efficiently.** These solutions are not mutually exclusive:

- Set a penalty for not meeting the performance targets for technical and commercial losses
- Recalculate the Regulated Values in the next FTP to reflect achievable performance targets
- Replace the separate losses performance targets with a single performance target, calculated as a percentage of net generation.

As discussed in section 5.1.1, BEL is not penalized if it fails to meet the performance targets for technical and commercial losses. This incentive structure is unusual relative to its peers. For example, in Dominica, Guatemala, and Jamaica, the electric utilities all operate under some form of a system loss cap.[34] If these utilities fail to keep losses at or below the cap, the utility must bear the cost of lost power in excess of the cap.

[33] This minimizes the risk to the ESCO; since Belize is a new market for this contract form, private providers may initially be wary of investing their own capital into the building retrofits.

[34] In Dominica, the electric utility (DOMLEC) operates under a loss cap of 11.75 percent, and its actual system losses in 2012 were 11.3 percent. In Guatemala, the system loss cap is set for each distribution company according to what a hypothetical "efficient" firm would operate under, and actual system losses for the distribution companies in 2012 varied between 7 and 15 percent. In Jamaica, the electric utility (JPS) operates under a system loss cap of 17.5 percent, and its actual system losses in 2012 were 25.9 percent.

Of course, such a penalty would only make sense if the system loss targets were realistically achievable during the FTP. A simple remedy would be for the PUC to recalculate the Regulated Values[35] in the next Full Tariff Review Proceeding. Specifically, the PUC could consider increasing the kWh allowances for technical and commercial losses, so that they keep pace with forecasted demand growth. Effectively, this would reset the performance targets at a higher, and thus more achievable, level.

A simpler solution would be to implement a single target for system losses, calculated as a percentage of net generation. This target—especially if adopted as part of a penalty structure—would retain the regulatory intent of the existing design, with two added benefits. First, it removes the need for the PUC to reset the Regulated Values at the beginning of the FTP to reflect an acceptable level of losses. Rather, the losses target would be set directly. This would be simpler administratively, and would improve transparency. Secondly, a single performance target would allow BEL to focus on reducing system losses in a least-cost manner.

6.1.2 Information interventions for EE

Interventions that address information barriers provide parties who are unaware of the opportunities of EE with the information they need to be able to invest in EE.

Public awareness initiatives should be designed to ensure the general public knows about EE—starting from ongoing initiatives by the Government, and the results of this study.

A **labeling system for EE products** should be adopted to help customers know the relative efficiency of equipment they buy. This should be done in coordination with other countries in the region, several of which are being supported by IDB (such as Barbados, or Jamaica). Developing new full labeling systems for Belize would be too costly. Belize is participating in the Energy for Sustainable Development in the Caribbean (ESD-Caribes) which aims to create standards and labeling for EE products in the Caribbean; Government should continue to pursue this initiative.

Creating minimum energy performance standards for energy consuming products would be another way to overcome the information barrier faced by consumers. If inefficient products are not sold, the lack of information about performance standards would no longer be a major barrier to using energy efficient products, as all products would be relatively more efficient. However, this type of intervention limits personal freedom to choose which types of products to use; for example, some people may prefer the light from incandescent bulbs to that of CFLs. Implementing a minimum energy performance standard would limit those people's ability to use the product they prefer. It could also hurt poor households since often the more efficient equipment would have a higher up front cost than the banned equipment, even if the more efficient equipment saved money in the long run. Any regulation that creates minimum performance standards would need to weigh the costs and benefits of such regulation carefully.

If **information about well-performing EE measures is backed up by warranties** or similar schemes, that information will be more credible. This would be particularly relevant

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[35] "Regulated Values" refers to the following variables, as defined in the 2008 Rate Setting Methodology: $E_{TL,0}$; X_{TL} ; $E_{CL,0}$; and X_{CL}. For a complete explanation of the variables and methodology see the PUC's 2008 Rate Setting Methodology.

for consumer finance schemes created for EE in Belize (and small RE systems). Any supplier of equipment and services that participates in such a financing scheme could be required to offer equipment that is labeled in accordance with the system adopted, and that includes a good warranty. The strongest and most credible version of a warranty would be the one where, if the equipment does not perform as promised and subject to certain conditions of use, repayment of a loan may be interrupted but the buyer keeps the equipment. Such a scheme could be, in turn, backed up by some guarantee or risk-sharing facility set up with donor money.

Training in the form of workshops, on-the-job activities, or embedded experts for 'pilot periods' of any consumer financing schemes would be designed to increase familiarity with EE costs and performance (assuming the basic skills are there, and only need awareness about a new context in which to use them). It could be combined with training to strengthen or create specific skills.

Government could also develop regulation to **require buildings to have energy management systems.** These energy management systems could apply to buildings with consumption above a certain level (for example, buildings consuming 15,000 kWh or more per month). The energy management system would consist of a plan to monitor the building's consumption patterns, as well as a team of people (using the current staff) who would review the performance information. If the building was not meeting its targets, the team could suggest interventions to improve performance. In considering this policy Government would need to consider the costs and benefits of this program to building owners, as well as the costs and benefits to the Government to implement and monitor such a program.

Adopting a certification system for EE services would help overcome the information asymmetry between providers and customers of such services. Even in this case, there would be no need to create new certification systems for Belize. Existing international ones could be endorsed by the Government to signal that those who possess them are considered to be qualified service providers. Some examples of certifications that could be adopted in Belize are:

- The Certified Energy Auditor (CEA) program offered by the Association of Energy Engineers (AEE)[36]
- The Certified Energy Manager (CEM) course, also by AEE[37]
- An Energy Auditors Fundamentals online seminar also offered by the AEE.[38]

6.1.3 Regulatory interventions for EE

These interventions align the interests of BEL with those of their customers.

[36] Association of Energy Engineers, "Certified Energy Auditor Program for Professional Certification," http://www.aeecenter.org/i4a/pages/index.cfm?pageid=3365

[37] Association of Energy Engineers, "Certified Energy Manager Program for Professional Certification" http://www.aeecenter.org/i4a/pages/index.cfm?pageID=3351

[38] Association of Energy Engineers, "Energy Auditing Fundamentals Online Seminar," http://www.aeeprograms.com/realtime/EnergyAuditing/

Improving BEL's revenue decoupling mechanism would provide a stronger incentive for BEL to help its customers be more energy efficient. Currently, BEL is being encouraged to improve customer efficiency, and it has started an initiative with some of its largest customers. To some extent, this initiative would help BEL if measures implemented by its largest load centers contribute to smoothing the load, allowing BEL to operate more efficiently. However, more widespread measures with more customers may just lead to a loss of revenue. There are proven demand-side management schemes worldwide that allow utilities to earn revenues also based on efficiency targets for their customers. Such schemes operate in 16 US states,[39] including California, Massachusetts, Ohio, and New York; they are being implemented in others.[40]

BEL could be well-positioned to operate as an ESCO—one that has a proven billing system with all of the country's customers, which it could use to recover the cost of its interventions. Any scheme would have to be designed so that customers only pay for services they actually get, and not for end-use measures that other customers enjoy. For example, if BEL improved the insulation of a particular home and upgraded that home's air conditioning, then those costs would be paid by the residents of that home and not by other BEL customers. However, the costs of grid and transmission efficiency upgrades would continue to be distributed over BEL's customer base as they are now; these upgrades would not be considered part BEL's ESCO activities. ESCO services could also be unregulated, meaning outside the scope of BEL's license and the Electricity Supply Act. BEL would compete with other providers in the market.

BEL's general efficiency measures that equally benefit all customers, on the other hand, should be made easily recoverable through general tariffs.

Further, increasing customers' energy efficiency may lead to a 'rebound effect' that increases consumption—although this would be more efficient consumption, meaning less consumption relative to output. Such an effect would not necessarily be a bad thing; it would bring greater productivity to companies, more welfare to households, and more revenues to the utility.

6.1.4 Market interventions for EE

Market interventions are designed to jolt the market into its optimal state—where EE equipment and services are available at a reasonable price, and in a quantity that matches demand for them. Even in a small market like Belize, there are opportunities for greater economies of scale. Belize also has the opportunity to benefit from the relatively large nearby markets of Mexico and Guatemala (unlike island Caribbean island countries). All of the EE measures included in the NSES scenario should be viable without government incentives or a reduction in import duties, if reasonable economies of scale can be achieved.[41] Put another

[39] A complete list of states with decoupling policies can be found at the Center for Climate and Energy Solutions website at: http://www.c2es.org/us-states-regions/policy-maps/decoupling

[40] For a further explanation of how decoupling works for utilities see: "Revenue Regulation and Decoupling," Lazar, et al, The Regulatory Assistance Project (2011).

[41] If certain EE technologies are a particular priority to implement, Government can consider reducing import tariffs, though according to our analysis this should not be necessary.

way, the Government would not need to give up revenues on imports of equipment in order to support EE measures.

A **consumer finance scheme** could be designed to bring greater volumes of EE equipment to the market at more competitive prices. The scheme could be set up directly between a donor such as IDB and equipment providers: concessional financing could be extended to them (in the form of lower-than-market credit lines, guarantees, or money for rebate schemes) under the condition that they offer better lending for EE to their customers. Hire-purchase schemes are common in the Caribbean and Central America, but usually have annual rates that are extremely high. It is possible that such schemes leave out a substantial portion of population, which finds them too onerous. A dedicated consumer finance scheme could improve on such existing and well-experimented mechanisms.

6.1.5 Financial interventions for EE

Financial interventions aim to ensure that creditworthy borrowers have access to financing for EE at rates commensurate with the risk of the investment in EE; and that less creditworthy ones also access financing on concessional terms.

Below we discuss two financial interventions to promote EE:

- A public sector financing mechanism, which seeks to better align agency incentives for EE through a dedicated Fund with favorable financing terms, and
- A set of private sector financing mechanism, which would unlock access to competitive financing for EE retrofits throughout the economy.

Public sector EE financing

In 2012, the Government spent an estimated BZ$24 million on electricity. About half of this expenditure was for street lights; the other half was for offices, schools, healthcare facilities, and other public buildings. These costs put pressure on Belize's already strained public finances.

The Government could reduce its electricity expenditure by up to BZ$8.6 million per year by investing in EE in its facilities. The net savings (BZ$8.6 million) are the difference between the annual savings (BZ$12 million) and the amortized cost of the EE retrofits (US$3.4 million). Even if electricity prices fell by half, EE retrofits would still save more money than they cost.

The Government could make an initial investment toward achieving these savings now, using a revolving Sustainable Energy Fund ('the Fund'). We assume that donor funding is available to capitalize the Fund—for example, BZ$20 million provided by IDB and another donor as concessional loans, and BZ$4 million provided by a Global Environment Facility grant.

The combined BZ$24 million could be used first to finance retrofits of just over half of all streetlights. Retrofitting streetlights first would simplify the procurement process and would help ensure the success of the initial investment. This measure alone is estimated to generate annual energy savings of BZ$3.6 million, net of amortized capital costs. This translates to net savings worth BZ$66 million over the 20-year lifespan of the streetlight retrofits.

As the savings begin to flow back to the Government, it could use these cash flows to pay for additional retrofits. For example, it would make sense to retrofit all remaining streetlights. The Government should also consider selective EE measures across all public buildings. These measures could include: window retrofits; cool building measures; AC upgrades; lighting upgrades; and replacement of aging appliances.

Private sector EE financing

The table below shows an estimate of the market size for implementing EE retrofits in the residential, commercial, and industrial sectors of Belize (based on the same modeling exercise used to estimate overall costs and benefits of the NSES presented in Section 2).

Table 6.2: Estimated Financing Requirements for EE in Private Sector, 2014-2033

Sector	NPV EE CapEx (BZ$)
Residential	$71,066,402
Commercial	$174,439,980
Industrial	$10,579,157

Options for financing mechanisms for the private sector are the following. A financing initiative could implement just one of these, or a combination of them, depending on financing available and appetite of commercial banks:

- **Concessional loans**: these are loans extended on terms that are more favorable than those available on the commercial market. For example, lower-than-market interest rate, longer-than-market tenor, a (longer) grace period. Concessional loans are especially indicated when there is a lack of liquidity in the private sector; although they can also be used to stimulate private sector competition—as long as it is not crowded out
- **Grants**: these are sums that are not to be repaid, and can be used for a variety of purposes. Partial or even total rebates can be used to incentivize the uptake of specific technologies, kick-starting a market for them. Feasibility studies can be funded for free to support EE or RE project preparation; concessional grants (or concessional loans) link the grant element to there being actual implementation, transforming a loan into a grant if a project is implemented, or transforming a grant into a loan if it is not. Technical assistance for commercial banks can be paid for with grants, for example providing embedded experts for a period of time to build their capabilities in EE and RE lending
- **Risk-management mechanisms**: these are particularly indicated to leverage private sector funding by lowering or eliminating collateral requirements. They can be designed to decrease in time, to incentivize the private sector to develop information and know-how for EE and RE lending during a period in which their exposure to risk is reduced. Loan guarantees and risk sharing facilities are common examples.

6.1.6 Skills interventions for EE

These interventions focus on **providing public and private operators with the skills to assess, design, and implement EE projects**. These trainings would be related to those discussed in Section 6.1.2—but would be more specialized to focus on specific skills and expertise as opposed to just awareness. For example, Government officials, installers, and electricians could receive formal training on EE provided by external programs. Banks could receive training on how to assess lending opportunities for EE; training could be focused on credit reviews, and done by experts embedded in commercial banks, to develop a portfolio of operations that then could be used as standard practice.

6.2 Overcoming Barriers to Distributed Renewable Generation

Three recommendations would help distributed RE generation in Belize reach its full potential once it becomes fully viable:

- Provide a well-structured Standard Offer Contract for distributed renewable generation
- Disaggregate the tariff structure to charge separately for energy, backup and standby, and connection to the grid
- Certify third-party inspectors for distributed RE systems.

6.2.1 Provide a well-structured Standard Offer Contract for distributed renewable generation

A well-structured Standard Offer Contract (SOC) for distributed generation would be set up to purchase energy:

- From eligible customers, with
  - **A cap on individual systems**—residential/non-residential, based on customer load (primarily for self-generation), physical limits, and characteristics of the distribution network
  - **A cap on overall installed capacity / number of systems**—to control financial and technical impact on service. The overall cap could evolve in time as experience builds up and integration of intermittent generation improves
- **For a pre-determined period of time**—consistent with the economic lifetime of systems (typically 20 years), in order to provide certainty to investors
- **Subject to technical requirements**—compliance should be required with a standard interconnection agreement to preserve safety, reliability of service, power quality and stability; this standard agreement would make it easier to inspect systems for compliance, and provide certainty to installers. There is no interconnection code or standard interconnection agreement for the distribution network. These would need to be developed, perhaps adapting best practices from a neighboring country
- **Accompanied by appropriate tariff arrangements**—this would ensure that interconnected customers pay for services of backup, stand-by, and connection to the grid (we discuss this in detail in Section 6.2.2)
- **At a pre-determined (but not necessarily fixed) price** that is fair to consumers who implement a system, consumers who do not implement a system, and BEL. Paying the avoided cost (for example, that of imports from CFE) would provide a good incentive while not increasing the overall cost of supply to the country.

Paying the retail rate (as happens under net metering) or a rate higher than that may encourage higher adoption, but would raise the cost of supply because some portion of the supply would come at retail price instead of avoided cost.

In addition, those eligible customers who apply and are admitted to participate in the SOC with a system above 75kW, but below some other limit appropriate for distributed generation (for example, 150kW), could receive an automatic license. System size limits are sometimes called a system size 'floor values.' This would not be a waiver of the license—therefore, it would not contravene the Law. Rather, it would represent an expedited licensing track for distributed generation systems of a size that does not justify case-by-case regulatory scrutiny (and transaction costs).

One way that some jurisdictions have developed their floor value policy is to begin with a conservative floor value and a regulatory trigger that when reached initiates a review of the interconnection rules. The trigger could be a specific distributed capacity target (for example, 5MW of total installed capacity). Belize could adopt a similar approach. When the capacity target is reached, the PUC could initiate a proceeding with BEL and other stakeholders to discuss the possibility of raising the floor. Fortunately, the Act states that the Minister or the PUC (with the approval of the Minister) may make regulations with respect to 'the forms of licenses' (Section 53(1)e).

6.2.2 Disaggregate the tariff structure to charge separately for energy, backup and standby, and connection to the grid

A tariff structure that encourages distributed RE generation while preserving BEL's financial viability would be disaggregated and cost-reflective, charging consumers separately for:

- Supply of energy, measured in kilowatt hours sold (energy charge)
- Connection to the distribution system (connection charge)
- Provision of generating capacity (capacity charge).

Under such a structure, customers of BEL who self-generate with solar PV even for their entire energy (kilowatt hours) needs would continue paying BEL for the other services that BEL provides to them.

It is likely that designing such a structure would require a cost of service study.

6.2.3 Certify third party inspectors for distributed RE systems

In most countries with extensive uptake of distributed generation, inspection is not done by utilities but by certified third parties. This relieves strain on utilities' resources, and also contributes to developing privately-supplied services in the market. In addition, it often eliminates many of the delays in commissioning a distributed RE system that might otherwise exist if the utility were solely responsible for inspection. Some examples of certification programs for renewable energy are:

- Online and in-person courses by Solar Energy International train and qualify technicians to install solar panels[42] and wind turbines[43]

42 Solar Energy International. Solar Training" Accessed online at: http://www.solarenergy.org/solar-training-electric

- Online certifications in Clean Energy Project Feasibility Analysis by Green Power Environment Knowledge Systems (GPEKS)[44]
- A Renewable Energy Generation with PV (REPV) course by the North Carolina State University[45]
- Courses on Alternative Energy Systems by the Virginia Tech Center for Energy and the Global Environment.[46]

6.3 Overcoming Barriers to Utility Scale Renewable Generation

Targeted policy, regulation and finance interventions can overcome the specific barriers identified in Section 5.3. These are summarized in the table below.

Table 6.3: Legal and Regulatory Barriers and Solutions for Utility RE

Types	Barrier	Recommendations
Information	Lack of investment grade resource assessments	Produce resource assessments
Regulatory	Ability to use a renewable resource: unclear situation for hydro sites in the Upper Macal River	Solve the issues related to BECOL's agreements and license
	Ability to access and develop a site: unclear framework for unprotected and protected areas—although Government policy set to address it	Continue according to what outlined in the NEP, developing specific permitting and planning for RE that balances environmental protection with economic benefit
	Ability to sell electricity commercially: (1) limited licensing regime, and (2) a few weaknesses in RE tendering	Develop a full licensing regime issued by PUC; include items required for licensing in the RFP package; provide a best practice standard PPA as part of the RFP package; clarify qualification and evaluation stages and criteria; define 'public resource'
Financial	Possible limited investor interest and higher costs for large RE in Belize	Provide clear rules and governance for investments

43 Solar Energy International. Wind Training" Accessed online at: http://www.solarenergy.org/wind-training-electric

44 Clean Energy Institute of GPEKS, "RS101 – Intro to Clean Energy Feasibility Analysis Course" http://info.cleanenergyeducation.net/node/19

45 NC State University, "Renewable Energy Generation with Photovoltaics," https://onece.ncsu.edu/search/publicCourseSearchDetails.do?method=load&courseId=96506&selectedCategoryId=5209&selectedProgramAreaId=&selectedProgramStreamId=

46 Viginia Tech University, http://www.bursar.vt.edu/tuition/index.php

Types	Barrier	Recommendations
Technical / Skills	Limited familiarity with grid interconnection of intermittent RE; limited experience operating RE plants not currently in use in Belize	Upgrade the Grid Code, and provide training and learning opportunities

6.3.1 Information interventions for RE

Developing RE resource assessments for biomass, hydro, and waste resources would overcome the information barrier that prevents good projects from being developed to take advantage of these resources. When appropriate, spatial data could be included in the resource assessments. Specifically for:

- **Biomass**—a comprehensive assessment of forestry waste quantity, quality, and location would indicate the potential size and location of a logging waste fired power plant. Studies of agricultural waste (plant and animal) at individual food processing and agricultural sites would allow the development of small scale anaerobic digesters
- **Hydro**—the 2006 Poyry study finds that many of the historic hydrological readings in Belize are of poor quality. It suggests implementing better hydro reading stations, as well as new hydro reading stations on unstudied hydro resources. Given the development of small and micro hydro technology, hydro resources previously judged too small for commercial generation may now be worth investigating
- **Waste**—a 2011 report on waste generation in the Western Corridor provides good general information on waste resources available in that region; a more targeted study on waste's usefulness in power generation is needed to develop a power project.

Such studies could be made publically available as part of a tendering process to develop these resources—similar to how the Government has provided existing studies under the Request for Proposals for Energy Generation, 2013. This would lower the barrier of entry for individual bidders, potentially generating more competitive bids.

6.3.2 Regulatory interventions for RE

These interventions develop the regulatory environment to ensure that it adequately accommodates the needs of RE and does not prevent economically viable projects from being developed.

Solve the issues related to BECOL's agreements and license

There are different interpretations of the status of BECOL's agreements and license; the lack of clarity may deter potential investors in hydro projects in Belize. Government should meet with BECOL and Fortis to resolve the issues related to BECOL's agreements and license. A successful outcome would need to: (i) allow qualified developers to legally develop good hydro sites on the Upper Macal River, and (ii) ensure that additional development does not damage BECOL's ability to operate its existing facilities at historic levels.

Continue developing specific permitting and planning process for RE

Government should continue to implement the measures in the NEP related to RE permitting and planning. Specifically, these measures include:

- **Giving a government agency a mandate to facilitate the RE development process**—this measure would give a government agency responsibility to provide assistance to private project developers navigating the permitting and planning requirements
- **Strengthening existing land use policy and demarcate RE zones**—this measure aims to clearly identify which land areas are designated to particular uses, based on the recommendations of the *Natural Resource Use Planning Study*; some zones can be specially designated for RE
- **Promoting stakeholder involvement in RE development process**—this measure would define a stakeholder consultation process for RE development
- **Developing a compensation scheme for property holders negatively impacted by RE development**—this measure would define a process to compensate property holders who may have their property value lowered by RE projects
- **Establishing environmental and visual standards for RE projects**—this measure would define where RE projects could be developed and what they could look like.

Develop a full licensing regime issued by PUC

A full licensing regime that encourages private investment in renewable generation could consist of an official document issued by the PUC pursuant to its statutory powers, and a licensing manual.

Regarding form, the **official document issued by the PUC** should be something other than a regulation pursuant to the Electricity Act. This is because the matters with respect to which the Minister, or the PUC with the approval of the Minister, may make regulations only includes the 'forms of licenses' (Electricity Act, Section 53(1)e) and not anything regarding their substance. There is no catch-all provision allowing a regulation to expedite the implementation of the Act. Therefore, any regulation on a licensing regime issued pursuant to the Electricity Act would be *ultra vires* (meaning, 'beyond statutory powers').

However, the PUC would be well advised to issue a document based on the duties and functions that the Electricity Act states are its responsibilities (Section 2 of the Act). To respect a general principle of administrative law, the document should not state that it limits the discretionary power that the PUC shall exercise; but simply that it explains how the PUC intends to exercise its discretion.

Regarding substance, the official document issued by the PUC could contain:

- **Rules for granting licenses**, covering
  - A few clear criteria based on which a license may be granted, such as: (i) safety and appropriateness of the location and type of facility, (ii) possession by an applicant of the financial capacity and technical capability needed to carry out the activity safely for people and the environment, reliably, and efficiently, (iii)

  having obtained the required permitting and planning authorizations, including environmental ones

  – Standards, linked to the criteria, that applicants need to meet

  – The things that the PUC intends to consider to judge whether the required standards are met, also linked to the criteria

  – Mention of the evidence that applicants need to provide to prove they meet the standard, also linked to the criteria—but the details of which would be listed in the licensing manual

  – The timing within which an application will be accepted or refused

  – The right for unsuccessful applicants to know why their application has been refused

- **Standard terms for which licenses are granted** that are consistent with the duration of the activity licensed
- **Rules for oversight**, covering
  – Standard conditions applicable to all licenses, or all licenses of a certain type

  – Reporting requirements linked to the conditions, allowing verification of compliance with the conditions

  – Ways to enforce compliance with conditions.

A **licensing manual** would make it easy for investors to navigate the rules and processes needed to carry out their activity in Belize by:

- Stating the rules, steps, and timing of the process to apply for, and obtain a license (or a notice of refusal, as well as of any appeal to a refusal)
- Listing the evidence required for all licenses, as well as for activity-specific ones, directly linked to the criteria stated in the legislative instrument
- Providing forms and templates complete with instructions.

Include items required for licensing in the RFP package

The RFP package should include, among other things, the information required to obtain a license. Currently, the RFP only says that a license shall be obtained pursuant to the Electricity Act, sections 14–29. Actually requiring bidders to submit items required for a license would allow the PUC to assess, as part of the tender, whether bidders are qualified for a license, thus accelerating the process.

Provide a best practice standard PPA as part of the RFP package

Providing as part of the RFP package a standard PPA that responds to best contractual practices would help investors, as well as Government counterparts in the negotiation stage. The standard PPA could just be a 'Heads of Terms' that summarizes the options chosen for the key provisions of the contract: terms and deadlines; payments for energy and capacity, and indexation; compliance with Grid Code and technical standards; provision for outages and step-in rights; liquidated damages; insurance; termination; and settlement of disputes.

There could be a Heads of Terms PPA for firm power, and one for intermittent power. These could be based on existing standard PPAs created at the time Hydro Maya, BELCOGEN, and the Vaca plants were developed. BEL has a standard PPA that could serve as a starting point to develop a Heads of Terms PPA.

Clarify qualification and evaluation stages and criteria

It could be useful to clearly present qualification and evaluation criteria in materials provided in the RFP for the tender. Qualification could be done based on well-specified criteria, for example expanding on those included in the Technical, Financial, and Management Component and the Socio-Economic Component. Qualification could be on a pass-or-fail basis (either bidders meet the requirements, or they do not), or on a minimum score basis (only bidders that obtain a certain score or more go on to the evaluation stage)—the latter would seem more consistent with what the RFP package already contains. Evaluation could alternatively just be done based on price.

Define 'public resource'

Bidders should be told what constitutes a 'public resource' so that they are prepared to enter into a Build-Own-Operate arrangement, or a Build-Own-Operate-Transfer arrangement.

6.3.3 Financial interventions for RE

Belize has a solid record of IPPs, and it looks likely to have more IPPs operating in the country following the conclusion of the current tender. Interventions that address the financial barriers to developing RE aim to create an environment in which private developers feel even more confident that they can make secure and profitable investments in good RE projects.

There are two main types of interventions that could accomplish this, accompanying a best-practice PPA. These measures need only be used if the costs presented by developers are too high or if developer interest is too low to run a best-practice tender process. The two measures are:

- **Getting a government pledge**—a sovereign guarantee to back up the PPA with BEL
- **Using credit enhancement measures**—multilateral development agencies such as the IDB or the International Development Association (IDA), the Multilateral Investment Guarantee Agency (MIGA), as well as the US Overseas Private Investment Corporation (OPIC) offer credit enhancement measures that decrease investor risk. Using these credit enhancement measures could decrease the rate of return required by investors. All three have a fee associated with them, so the cost should be weighed against the benefits of the measure:
  - **Partial risk guarantees** cover private debt against a government's (or government entity's) failure to meet specific obligations to a private or a public project, including expropriation, regulatory risk, and frustration of arbitration (among others). If a triggering event happens, partial risk guarantees typically cover outstanding principal and accrued interest of a debt tranche in full
  - **MIGA** provides insurance against losses caused by currency inconvertibility, government expropriation, political violence, and government breach of contract

- **OPIC** political risk insurance provides coverage against losses caused by currency inconvertibility, government expropriation, political violence; however, OPIC political risk insurance is only available to US investors.

6.3.4 Technical interventions for RE

In order to realize Belize's RE potential, the PUC and BEL should **develop more sophisticated procedures and regulations for interconnection of intermittent renewable energy**. Specifically, BEL should develop intermittency requirements for the Grid Code and a standard interconnection agreement for the distribution system, for when the arrangement being developed by the PUC enters into force. The skills of BEL's staff to manage intermittent generation and interconnection through the distribution system will also need to be developed in parallel.

Requirements for intermittent generation in BEL's technical grid code will allow the interconnection of larger intermittent renewable sources to the grid. These regulations would specify the technical requirements to safely integrate new intermittent sources while preserving grid stability; they would be tailored to the technical conditions of the grid, in particular the availability of spinning reserve from Mexico. If BEL does not have the skills in-house to develop the update to the technical grid code, technical assistance (supported by an international donor agency or the Government of Belize) could support development. BEL could also leverage its membership in Caribbean Electric Utility Service Corporation (CARILEC) to learn from other utilities in the region who have successfully integrated intermittent RE.

Developing guidelines for connecting generation to the distribution system (rather than the transmission system) would also allow for lower-cost integration of RE in Belize's grid. Currently there is no generation connected to Belize's distribution system. As noted, if renewable projects below 20MW in size are located close to both transmission and distribution, connection to the distribution system will most likely be more economical than connecting to the transmission system. To take advantage of these potential savings, BEL should develop guidelines for the connection of renewable generation to the distribution system.

In order to ensure that the requirements for interconnection of intermittent generation and connection to the distribution system are executed properly, BEL's technical staff will need to be trained to properly follow the requirements. The PUC has stated that the present BEL load controllers should require only limited training to be able to do this.

In order to fully realize Belize's RE potential, the Government should **support initiatives and activities that allow for RE training and technology transfer.** This could include sending Belizean delegations to conferences, engaging with ministries from other regional governments, or participating in multilateral programs focused on technology transfer. The Government could also consider developing a research and development institute, particularly if donors are willing to offset the cost. Any such program would have to be carefully considered and only pursued if cost-benefit justified.

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